

ANNALS OF SURGERY

VOL. 131

JANUARY, 1950

No. 1



USE OF BLOOD AND PLASMA IN CORRECTION OF PROTEIN DEFICIENCIES IN SURGICAL PATIENTS*

J. GARROTT ALLEN, M.D., WILLADENE EGNER, B.S., M. B. BRANDT, A.B.,
AND DALLAS B. PHEMISTER, M.D.

CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF CHICAGO. THIS WORK HAS
BEEN AIDED BY A GRANT FROM THE RUTH HANNA SIMMS FOUNDATION
OF THE UNIVERSITY OF CHICAGO

THE IMPORTANCE of correcting hypoproteinemic states in the surgical patient is well recognized. There is general agreement that this can best be accomplished by encouraging the patient to take large amounts of protein in his diet. In certain patients, however, oral feedings are either sharply limited or impossible because of the nature of their disease. This group must receive parenteral nitrogen therapy if their nutritive state is to be improved prior to the advent of surgical procedures.

Many surgeons have attempted, without much success, to restore the plasma protein concentration to normal by parenteral protein hydrolysate administration. While the patient may be placed in positive nitrogen balance, the degree of nitrogen retention is usually not sufficient to elevate the plasma protein concentration within a reasonable period of time. As a result, the depleted patient who can take little nitrogenous food is often operated upon without adequate correction of his depleted state.

The work of Whipple *et al.*¹ suggested that nitrogen administered as plasma was better utilized, in that a higher degree of positive nitrogen balance was obtained and that the plasma protein concentration could be restored to normal. These observations differed from those of Elman,² who maintained that there was a latent nitrogen loss occurring two or three weeks after plasma therapy which counterbalanced the gains achieved during the period of plasma administration. Clinical experience gained during World War II, however, suggested that plasma may be of considerable value in maintaining the patient in good nutritive state.³

For these reasons, a study of nitrogen metabolism in depleted patients has been undertaken in which protein administered was in the form of plasma or blood, either as the sole source of nitrogen, or as supplementing a known oral intake. It is the purpose of this report to illustrate a few of the observations made. Patients were placed in rooms where special attention could be given to caloric and nitrogen intake, and to the nitrogen lost in the

* Submitted for publication February, 1949.

urine and stool, and, in some instances, in gastric lavage and drainage from wounds. Dietitians and nurses, experienced in such routines, helped to make these studies possible.

THE EFFECT OF PLASMA ADMINISTRATION UPON THE PLASMA PROTEIN CONCENTRATION

In a previous paper from this laboratory,⁴ it was reported that plasma, in adequate amount, will achieve not only a high-grade positive nitrogen balance, but, in addition, will restore the plasma protein concentration to normal. The results obtained did not disclose evidence of latent nitrogen loss, so that, in the long run, fairly substantial gains were realized. The volumes of plasma required were larger than those generally used.

The daily protein requirement for the average normal adult person has been arbitrarily estimated to be in the neighborhood of 50 to 60 Gm. per day.⁵ The work of Cannon and co-workers suggests that when the protein

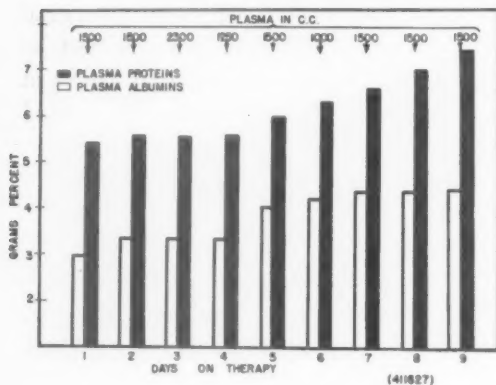


FIG. 1

FIG. 1.—Carcinoma mouth, tongue and esophagus (30 lb. chronic weight loss).

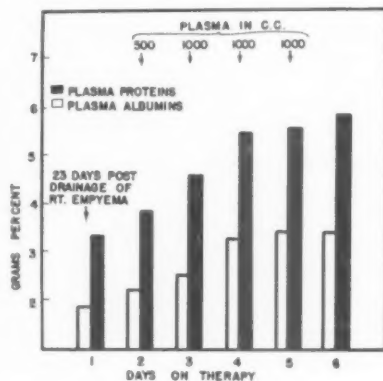


FIG. 2

FIG. 2.—Continuous drainage of thoracotomy wound (6 lb. weight loss).

(343491)

given is complete, even less may be required.⁶ Approximately one liter of citrated plasma daily should supply 50 Gm. of protein or 8 Gm. of nitrogen. This figure does not take into account the probability that the requirement in the depleted patient may be temporarily greater.

When such volumes of plasma were administered, the excretion of nitrogen was increased but slightly, so that a high degree of nitrogen retention was obtained. In some cases, where plasma and blood were given in conjunction with oral feedings, as much as 20 Gm. of nitrogen retention per day was observed.

The amount of plasma necessary to restore the normal plasma protein concentration, when 1000 cc. or more was administered daily, was related to recent weight loss. Patients with extensive weight loss in general required longer periods of plasma therapy (Fig. 1, 13,550 cc.—nine days) to restore

normal plasma values than did those with acute depletion (Fig. 2, 3500 cc.—five days).

The studies did not disclose a latent nitrogen loss following plasma administration (Table I). Presumably the plasma volume was increased after large volumes of plasma had been given. Subsequently, internal readjustment

TABLE I.—*Nitrogen Balance During and Following Plasma Therapy.*

	Plasma Protein Concentration in Gm. per 100 cc.		Plasma Protein Total Circulating in Gm.		Nitrogen Intake Daily Average in Gm.		Daily Average Nitrogen Output in Gm.	Daily Average Nitrogen Bal- ance in Gm.
	Beginning	End	Beginning	End	Oral — Parenteral			
Control Period 4 Days	4.6	5.1	201	244	9.8	0.0	12	2.2 Negative
Plasma Period 5 Days	5.1	7.1	244	340	15.0	12 (1500 cc. daily)	11.8	15.2 Positive
Control Period Following Plasma 28 Days	7.1	6.4	340	243	11.9	0.0	10.6	1.3 Positive

Patient with gastro-enterocolic fistula and stoma ulcer corrected by closure of fistula and vagotomy. Nitrogen balance data obtained from nitrogen balance studies before, during and for 28 days following plasma therapy. There was no evidence of latent nitrogen loss.

TABLE II.—*Nitrogen Balance of a Surgical Patient Receiving Whole Blood Transfusions.*

	Blood Vol. in cc.	Plasma Vol. in cc.	Pl. Prot. Gm. per 100 cc.	Total Cir. Pl. Prot. in Gm.	Hbg. in Gm. per 100 cc.	Total Cir. Hbg. in Gm.	Dly. Av. N. Intake in Gm.	Dly. Av. N. Out in Gm.	Dly. N. Balance in Gm.
	Begin-End	Begin-End	Begin-End	Begin-End	Begin-End	Begin-End	Oral-I.V.		
Control Period 2 Days	2700—	2200—	5.9–6.0	123.9—	6.3—	170—	11.6–0	9.8	1.8 Positive
Blood Period 8 Days Total of 6650 cc.	2700–5200	2200–3600	6.0–7.0	123.9–252	6.3–10.4	170–540	11.5–29.0	12.8	27.7 Positive
Post Trans- fusion Period 3 Days	5200–5000	3600–3300	7.0–6.8	252–224	10.4–10.8	540–540	11.4–0	12.7	1.3 Negative

This shows a less dramatic rise in the concentration of hemoglobin and plasma protein after the administration of 6600 cc. of blood in eight days. The blood and plasma volumes, seriously depleted by two diseases and operative procedure, revealed the true extent to which anemia and hypoproteinemia were present in this patient. The transfused blood restores to normal the total circulating hemoglobin and plasma protein concentration in this patient.

occurred, and the plasma proteins were probably converted into tissue proteins and the excess fluid excreted. The patient, whose findings are presented in this table, was studied for a period of 28 days following the completion of plasma therapy. Terry in Whipple's laboratory⁷ has recently reported that dogs were maintained in positive nitrogen balance for as long as three months with plasma as the only source of nitrogen, and again found no evidence of latent nitrogen loss.

THE PLASMA PROTEIN CONCENTRATION AS AN INDEX OF THE
NUTRITIONAL STATUS OF THE PATIENT

When the concentration of the plasma proteins is reduced it is probable that other proteins are also partially depleted. However, the plasma protein concentration did not always reflect the true status of even the plasma proteins.

A much better index was the status of the total circulating plasma proteins. This figure was obtained when the concentration of the plasma proteins was multiplied by the plasma volume. Normally, the total circulating proteins are approximately 4 Gm. per Kg. of body weight.

Since the plasma volume is reduced in starvation, the concentration of the plasma proteins may appear normal or only slightly reduced, when actually the total circulating plasma proteins may be seriously reduced (Table II). Madden *et al.*⁸ have shown that, as starvation proceeded, the plasma volume was reduced before the protein concentration was reduced. These workers reported that this situation was reversed when the starved animal was repleted, *viz.*, that the plasma volume was largely restored before changes in the plasma protein concentration could be detected. The first detectable changes in the plasma proteins in either depletion or repair, may not be in their concentrations, but rather in the total circulating plasma proteins.

COMPARISON OF THE EFFECTS OF AMIGEN AND PLASMA UPON THE
PLASMA PROTEINS AND NITROGEN BALANCE

Both amigen and plasma, when given intravenously, are capable of placing the patient in positive nitrogen balance. They differ sharply, however, in the degree of positive nitrogen balance achieved when comparable quantities of nitrogen are administered, as illustrated in Table III. The patient whose data are recorded in Table III had cancer of breast and radical mastectomy. Her appetite was poor and she consumed only 15.5 Gm. of nitrogen orally per day during the control pre-plasma period. This amount was slightly reduced voluntarily during the period of amigen therapy and slightly increased during the period of plasma administration. The quantity of nitrogen administered parenterally as amigen was 9 Gm. per day, and, as plasma, was 8.8 Gm. per day. The amount of nitrogen retained during the amigen period was 1.6 Gm. per day, while 11.9 Gm. per day was retained during the plasma period. The nitrogen balance achieved during plasma administration was about six times greater than during amigen therapy.

Shown in Table IIIA are the data obtained on the same patient during these periods with reference to the effects of amigen and plasma administration upon the plasma proteins. The plasma proteins were calculated in terms of their concentrations and also in terms of their total circulating plasma proteins. These data were computed from plasma volume determinations made at the beginning and end of each period. During amigen administration the plasma protein concentration fell slightly, but this was due more to an

PROTEIN DEFICIENCIES IN SURGICAL PATIENTS

increase in plasma volume, since the total circulating plasma proteins remained essentially unchanged. When plasma was given, the plasma protein concentration was elevated from 4.8 Gm. per 100 cc. to 6.4 Gm. per 100 cc.,

TABLE III.—*Comparative Effect of Amigen and Plasma Upon Nitrogen Balance (Postoperative Studies on Patient Who Had Radical Mastectomy).*

	Average Daily Caloric Intake in Gm.			Average Daily Protein Intake in Gm.			Average Daily Nitrogen Intake in Gm.			Average Daily Nitrogen Output in Gm.	Average Daily Nitrogen Balance in Gm.
	Oral	I.V.	Total	Oral	I.V.	Total	Oral	I.V.	Total		
Control Period											
4 Days	936	...	936	15.5	...	15.5	2.4	...	2.4	4.7	2.3 Neg.
Amigen* Period											
8 Days	1017	355	1372	25	37.5	62.5	4	9	13	11.4	1.6 Pos.
Plasma Period											
4 Days	1158	220	1378	53.5	55	108.5	8.5	8.8	17.3	5.4	11.9 Pos.

* Amigen Figures from Mead Johnson & Co. When amigen was administered there was an increase in nitrogen excretion. Nitrogen excretion was much less when the parenteral nitrogen administration source is plasma. This fact, brought out in this table, probably accounts for the much greater effectiveness of plasma compared to similar quantities of amigen.

and the total circulating plasma proteins were increased from 163 Gm. to 237 Gm.

It is probably not essential that the plasma proteins be restored rapidly to normal in all the non-operative patients. It may be possible to restore the protein needs by oral feedings and hydrolysate therapy in due course.

TABLE IIIA.—*Comparative Effect of Amigen and Plasma Upon Plasma Proteins (Same Patient as Shown in Table III).*

	Plasma Protein Concentration		Total Circulating Plasma Protein	
	Beginning	End	Beginning	End
Control Period				
4 days	5.9 Gm. per 100 cc.	5.5 Gm. per 100 cc.	165 Gm.	170.5 Gm.
Amigen Period				
8 days, 9 Gm. N./day	5.5 Gm. per 100 cc.	4.8 Gm. per 100 cc.	170.5 Gm.	163.2 Gm.
Plasma Period				
4 days, 8.8 Gm. N./day	4.8 Gm. per 100 cc.	6.4 Gm. per 100 cc.	163.2 Gm.	237 Gm.

In this table is brought out the fact that essentially no change in the plasma proteins followed an 8-day period of amigen administration, whereas approximately the same amount of daily plasma restored the plasma protein levels to near normal in four days.

However, the plasma protein concentration and total circulating plasma proteins apparently are not materially or rapidly elevated by amigen therapy alone. The liberal use of plasma and blood in the preoperative and early postoperative periods, or until the patient can take oral feedings, will result in a more rapid return of normal plasma values than can be accomplished by most present day hydrolysate therapy.

PLASMA INDUCED ANEMIA

When large and repeated plasma transfusions are given, mild to moderate degrees of anemia frequently develop. This was observed in all of our

patients who received one liter or more of plasma per day for three or more consecutive days. The anemia was not the result of hemodilution alone, since the changes in plasma volume were not sufficient to account for the reduction in hemoglobin concentration and red cell count. The total circulating hemoglobin was actually reduced, an example of which is shown in Table IV.

The cause of this anemia was not determined. There was no increase in the serum bilirubin and no evidence of hemoglobinemia or hemoglobinuria.

FIG. 3

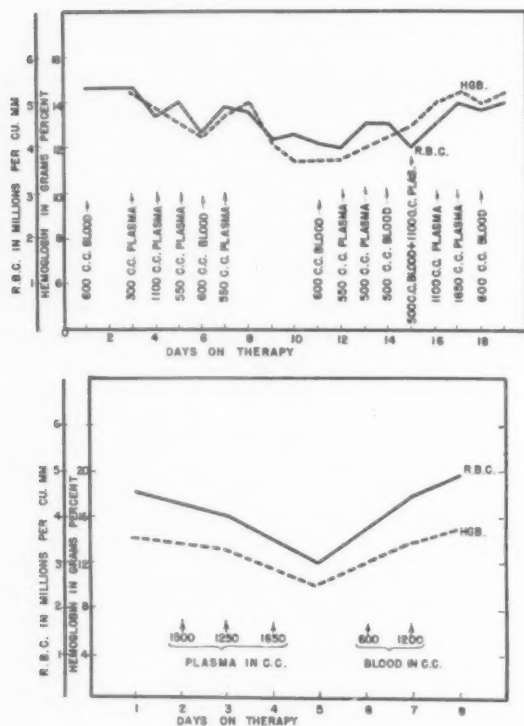


FIG. 3A

FIG. 3.—Maintenance of R. B. C. and hemoglobin by administration of blood during plasma therapy. (343601)

FIG. 3A.—Showing anemia following administration of 4400 cc. of plasma and recovery after 1800 cc. of blood. (402257)

hemoglobin can be utilized to replenish the protein needs of the body and to restore plasma proteins to normal. Intracellular hemoglobin is probably available for protein synthesis only when it leaves the cell.⁸ Studies on the length of life of transfused red blood cells show that some cells may be recognized in the recipient's blood even after three or four months.⁹ These

It may be that a low degree of hemolysis occurred, which was not detected by the methods employed. Hemolysis may be expected because of the unlikely possibility that the isoagglutinins of any pool of plasma are completely neutralized.

If blood transfusions are given in adequate amounts in the course of plasma therapy, anemia may be prevented (Fig. 3), or if anemia results from the plasma transfusions, it may then be corrected by blood administration (Fig. 3a).

WHOLE BLOOD TRANSFUSIONS AS A SOURCE OF PROTEIN

The protein content of whole blood, composed of 7 Gm. per 100 cc. as plasma proteins and about 16 Gm. per 100 cc. of hemoglobin, represents a large source of transfusible protein, about 23 Gm. per 100 cc., excluding citrate volume. It is problematic whether intracellular hemoglobin can be utilized as tissue or plasma protein. Whipple has shown that extracellular

studies, made on relatively normal subjects for the most part, indicate that the hemoglobin of the red cell is not readily available as a source of protein for other body needs. We have obtained some evidence, in three severely depleted patients, that intracellular hemoglobin may be a more labile protein than was formerly thought (Tables II and VA). Both patients had severe anemia and reduction of plasma proteins and blood volumes, and areas of local infection. In Patient S., Table VA, 5200 cc. of blood were given, over

TABLE IV.—*Chart Shows a Reduction of the Total Circulating Hemoglobin in a Patient with Marked Hypoproteinemia from Starvation, Due to Cancer of the Esophagus.*

Days on Plasma	Pre-trans-									
	fusion	1	2	3	4	5	6	7	8	9
Plasma transfused in cc.	0	1500	1500	2350	1250	1500	1000	1000	1000	1500
Total Circulating Hemoglobin in Gm.	494	....	....	460	....	....	384	....	....	308

a six-day period, without evidence of any increase in blood volume, hematocrit reading, hemoglobin or red cell count. This volume of blood was in excess of the original blood volume. The nitrogen excretion was not appreciably increased and gave no indication of the fate of the transfused blood, Table V. Seventeen hundred cc. more were given in the next four days. The daily nitrogen loss through the drainage site of the subphrenic

TABLE V.—*Utilization of Whole Blood in a Protein Depleted Patient (Perforated Duodenal Ulcer with Postoperative Hemorrhages and Subphrenic Abscess That Was Drained Surgically).*

	Average Daily Nitrogen Intake in Grams			Average Daily Nitrogen Excretion in Grams				Average Positive Balance
	Oral	I.V. Blood	Total	Urine	Stool	Dressings	Total	
Post subphrenic abscess drainage.								
First 10 days with transfusions	11.1	25	36.1	10.2	2.0	0.5	12.7	23.4
Second 10 days post transfusions	12.6	0.0	12.6	8.1	1.6	0.0	9.7	2.9

5200 cc. of blood were administered to this patient during the first six days without altering the blood volume, the hemoglobin concentration, or the hematocrit reading as shown in Table VA. During the next four days, 1700 cc. of blood were given with significant elevations in these measurements.

abscess was measured by washing the dressings. The entire nitrogen loss in the dressings during the ten day transfusion period totaled 5.0 Gm. and averaged 0.5 Gm. of nitrogen daily. This loss of nitrogen was considerably less than the total protein nitrogen content of one whole blood transfusion.

The changes in blood volume, produced by whole blood transfusions, in these patients were greater than those produced in patients by similar volumes of plasma. The principal change in the blood volume occurred in the red cell mass, although the plasma volume also was moderately increased.

In the same manner, the increase in the blood proteins was greater in the hemoglobin fraction than in the plasma protein constituents. Other patients, less severely depleted, showed a tendency toward plethora before many whole blood transfusions were given.

COMMENT

For the most part, the data presented in this report were obtained from patients in whom it seemed advisable to correct the existing protein deficiencies as rapidly as possible, in order that the required surgical procedures be not unduly delayed. When time is not important, rapid restoration of plasma proteins may not be needed. In these cases amino acid hydrolysates, administered orally or parenterally as food supplements, may be of

TABLE VA.—*Showing Changes in Circulation and Blood Elements After Repeated Blood Transfusions (Same Patient as in Table V).*

	RBC in Millions per cu. mm.		Cell Volume per 100 cc.		Hemoglobin in Gm. per 100 cc.		Plasma Proteins in Gm. per 100 cc.		Total Cir. Plasma Prot. in Gm.		Total Cir. Hemoglobin in Gm.	
	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End
10 Day Transfusion Period.												
At end of first 6 days	4.0	4.2	38	39	11.6	12.4	5.2	6.0	78	90	278	325
Total Blood—5200 cc.												
At end of tenth day of transfusions	4.2	6.1	39	55	12.4	16.2	6.0	6.8	90	102	325	528
Total Blood—6900 cc.												
Post transfusion period 10 days	6.1	5.6	55	49	16.2	16.0	6.8	6.2	102	110	528	560

value. On the other hand, where surgical procedures are necessary before oral nitrogenous food can be taken, parenteral nitrogen therapy is essential if the nutritional status of the patient is to be improved prior to operation. In such patients it may be very important to overcome large protein deficiencies in short periods of time. Blood and plasma given in adequate amounts, can meet these needs better than parenteral protein hydrolysates.

Unless reasonable judgment is exercised, patients may be over-transfused, both with respect to whole blood and/or plasma. The seriousness of over-transfusion is largely the danger of circulatory overload. The ill effects of overload depend principally upon the cardiac reserve of the patient and the speed with which the blood or plasma volume is increased. In the depleted patient, cardiac reserve may be reduced, thus increasing the likelihood of danger from overtransfusion. The circulation is more easily overloaded in the pre- and postoperative periods than during operation, when blood is usually given as it is lost and in amounts approximating blood loss. Fortunately, most of the plasma proteins transfused in the depleted patient remain in the blood stream for only brief periods of time. The water contained is lost even more rapidly, so that no significant changes in

plasma volume may be demonstrated five or six hours after a 500 cc. plasma transfusion. Hence, in depleted patients with reasonable cardiac reserve, we have seldom detected evidence of cardiac overload when 500 cc. of plasma is administered slowly twice daily, with at least six-hour intervals between transfusions.

When whole blood is transfused, the danger of overload may be slightly greater, for the red cell mass is generally increased. This increase, however, may be surprisingly slow in the patient with long-standing hypoproteinemia and anemia as shown in Table VA. In the normal nutritional state, the transfused red cell mass is better retained. In such patients, repeated whole blood transfusions may result in temporary polycythemia associated with a transitory increase in blood volume. But moderate polycythemia and hyperproteinemia may be better tolerated at operation than the more severe grades of anemia and hypoproteinemia encountered in the depleted and untreated patient. Much more frequent and serious is the error of giving too little rather than too much blood or plasma.

It is possible that the plasma and blood electrolytes may be increased above normal when large volumes of blood and/or plasma are administered. In our small series of cases we have not observed this phenomenon.

Reactions to both blood and plasma may occur. Generally, when typing errors are not made, the overall reaction rate can be kept below 3 per cent. More recently, the recognition of so-called "homologous serum jaundice" has created a problem in preventing reactions, in that the donor may transmit the filterable agent prior to his knowledge of the disease, and also for three to four months after his disease. Again, the fact that the plasma from one donor may contaminate an entire pool magnifies the problem greatly. In our own blood bank, we have, since its inception, rejected donors with a history of jaundice. Whether this or other fortunate circumstances account for the fact that only 28 of our recipients have been known to develop latent jaundice remains to be seen. Nine of these patients received Red Cross plasma in addition to blood from our own bank. In all, we have given over 27,000 transfusions of blood and plasma since our blood bank was established in 1942.

From the data now available,^{1, 3, 4, 7, 10} it appears that in patients unable to take an adequate diet, plasma and blood are superior to amigen, the protein hydrolysate, in correcting protein deficiency. Amigen will maintain nitrogen equilibrium, and may well be used for this purpose after protein deficiencies have been corrected; but there is little evidence that the plasma proteins can be quickly and materially improved by amigen alone, even though it is administered in amounts of 1000 to 2000 cc. daily. Oral feedings offer both the most efficient and economical means of repletion, but where parenteral protein therapy is essential, blood and plasma appear superior to present day substitute therapy.

The initial cost of blood and plasma is much greater than the cost of

similar quantities of amino-acid hydrolysates, if both have to be purchased. In the long run, however, this difference may prove artificial. In these costs must be considered the prolonged hospital course required when the amino-acid hydrolysates are given, and that this prolonged hospitalization also means for some patients greater loss in earning power. On the other hand, if an effective donor collecting system can be created by an agency such as the American Red Cross, better and far less expensive pre- and postoperative parenteral protein therapeutic programs will be available.

SUMMARY

1. Intravenous plasma appears to be utilized more efficiently than intravenous amigen as a means of correcting plasma protein deficiency, both with respect to nitrogen balance and elevation of the plasma proteins. No latent nitrogen loss is detected.

2. Evidence is presented which suggests that intracellular hemoglobin in whole blood transfusions may be utilized for body protein in the depleted patient. A greater degree of utilization appears to take place in the more severely depleted patient.

3. The rises in hemoglobin and hematocrit readings were disappointingly slow, and the values obtained were considerably less than should be expected, had all the hemoglobin contained in the transfusions been retained in the circulation. These data suggest that the body's utilization of hemoglobin for tissue protein may explain why the response to whole blood transfusions is often slow. Further studies are indicated.

4. Reactions to either blood or plasma transfusions were not sufficiently frequent or severe to discourage such therapy as a means of correcting hypoproteinemic states. The problem of "homologous serum jaundice" can be minimized by rejecting donors with a history of jaundice. In our experience, this problem is not a justifiable reason to reject plasma transfusions for nutritive purposes.

5. Circulatory overload may occur if care is not exercised in the administration of either blood or plasma transfusions. The rapid disappearance of water from the circulation, and the fairly rapid disappearance of plasma proteins, are the main factors which safeguard against overload. Polycythemia and hyperproteinemia may be as well tolerated by the surgical patient as marked anemia and hypoproteinemia, and the danger of moderate overtransfusion is probably much less than the hazards of undertransfusion.

6. In starvation, the concentration of plasma protein and hemoglobin may remain normal for considerable periods of time, because the first change is a reduction in the blood volume. If the total circulating plasma protein and hemoglobin are calculated, the effects of depletion are detected much earlier.

7. The much more efficient utilization of blood and plasma as nitrogenous nutrients, compared to protein hydrolysates, largely offsets the cost differential when blood is donated. There is great need for a nation-wide transfusion

service, for which patients would pay or not, according to their economic status. The development of such a service should be encouraged.

BIBLIOGRAPHY

- ¹ Holman, R. L., E. B. Mahoney and G. H. Whipple: Blood Plasma Protein Given by Vein Utilized in Body Metabolism. *J. Exper. Med.*, **59**: 269, 1934.
- ² Elman, R., and H. W. Davey: Studies on Hypoalbuminemia. Produced by Protein Deficient Diets. III. The Correction of Hypoalbuminemia by Means of Large Plasma Transfusions. *J. Exper. Med.*, **77**: 1, 1943.
- ³ Snyder, H. E.: Blood Plasma. *Surg., Gynec. & Obst.*, **84**: 1125, 1947.
- ⁴ Allen, J. G., G. Bogardus, W. Egner and D. B. Phemister: Correction of Hypoproteinemia by the Administration of Plasma and Blood. *Surg., Gynec. & Obst.*, **86**: 1948.
- ⁵ Best, C. H., and N. B. Taylor: *The Physiological Basis of Medical Practice*. Fourth Edition, pp. 665-666, 1945, Williams & Wilkins, Baltimore.
- ⁶ Cannon, P. R.: Personal Communication. 1948.
- ⁷ Terry, R.: Prolonged Parenteral Plasma Produces Hyperproteinemia and Proteinemia in Dogs and Maintains Nitrogen Equilibrium and Health. *Federation Proc.*, **7**: 281, 1948.
- ⁸ Madden, S. C., C. A. Fink, W. G. Swalbach and G. H. Whipple: Blood and Plasma Protein Production and Utilization. *J. Exper. Med.*, **71**: 283, 1940.
- ⁹ Hawkins, W. B., and G. H. Whipple: The Life Cycle of the Red Blood Cell in the Dog. *Am. J. Physiology*, **122**: 418, 1938.
- ¹⁰ Kremen, A. J.: The Problem of Parenteral Nitrogen Administration in Surgical Patients. *Surgery*, **23**: 92, 1948.

STREPTOCOCCAL ENZYMATIC DEBRIDEMENT*

WILLIAM S. TILLET, M.D., SOL SHERRY, M.D., L. R. CHRISTENSEN, Ph.D.†
ALAN J. JOHNSON, M.D., AND GEORGE HAZLEHURST, M.D.

NEW YORK, N. Y.

FROM THE DEPARTMENT OF MEDICINE, NEW YORK UNIVERSITY COLLEGE OF MEDICINE
AND THE THIRD MEDICAL DIVISION, BELLEVUE HOSPITAL, NEW YORK

IT HAS BEEN RECENTLY demonstrated that concentrates derived from cultures of hemolytic streptococci containing streptokinase (streptococcal fibrinolysin) and streptodornase (streptococcal desoxyribose nuclease) can be introduced locally into the thoracic cavity of patients in sufficient quantities to effect substantial and rapid enzymatic changes without causing serious untoward reactions.¹

It is the purpose of this report, which is an extension of previous ones on several detailed aspects of this subject,²⁻⁵ to describe the well-defined clinical therapeutic results that have been obtained by the treatment, through local injection of the lysing enzymes into selected groups of patients.

The patients who have been treated suffered from diseases characterized by the undesirable presence of fibrinous or purulent exudations. The categories into which they so far fall are as follows:

1. Loculated, post-pneumonectomy hemothorax.
2. Traumatic hemothorax.
3. Sterile loculated empyema.
4. Bacterial empyema.
5. Other local infections (osteomyelitis, paranasal sinusitis, etc.).
6. Miscellaneous chronic ulcerative lesions.

Detailed data and comprehensive analyses of each of the groups is planned for subsequent publications. In order, however, to illustrate the nature of the results that are being obtained, the descriptions which follow are limited to an example of each of the types of patients that have been treated. Since photographs demonstrate the results more clearly and objectively than verbal descriptions, each of the cases is presented with accompanying figures and the text has been reduced to the minimum.

The partially purified streptococcal concentrates employed have been prepared according to methods originally developed by one of us (L. R. C.).^{4,†}

Both streptokinase (to be, for brevity's sake, referred to as SK) and streptodornase (to be referred to as SD) were present in the partially purified

* This study was supported by a grant from the National Institute of Health, U. S. Public Health Service. Submitted for publication May, 1949.

† Department of Microbiology, N. Y. U. College of Medicine. Work supported in part by a grant from the Life Insurance Medical Research Fund and the Ralph B. Rogers Rheumatic Fever Fund.

‡ A considerable amount of the preparations was supplied by Lederle and Co.

STREPTOCOCCAL ENZYMATIC DEBRIDEMENT

FIG 1

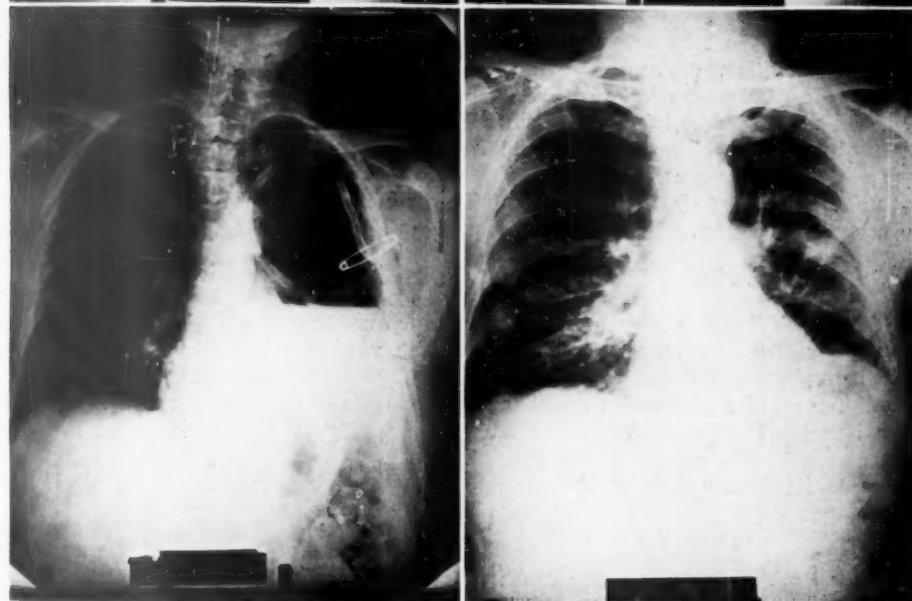
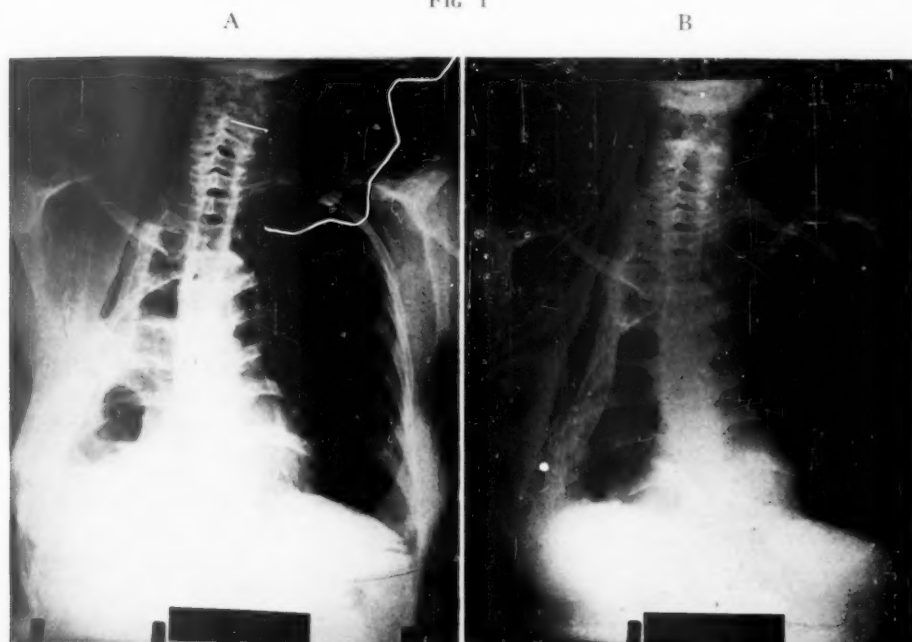


FIG. 2

FIG. 1.—Patient A. L. Loculated, postoperative, hemothorax. (A) Before treatment. Loculated areas evident. (B) Twenty-four hours after treatment. 650 cc. of fluid removed by aspiration.

FIG. 2.—Patient H. F. Traumatic hemothorax. (A) Tube below level of fluid but drainage ineffective. Complete collapse of lung present. (B) Roentgen ray taken at time of discharge from hospital, 55 days after beginning of treatment.

preparations used for injection. Although the quantities of each varied in different preparations, the individual dosage for intrathoracic use varied from 100,000 to 400,000 units of SK and 5000 to 40,000 units of SD. The combined units of each were contained in 2 to 10 cc. of physiologic salt solution. Where the areas of disease were smaller (such as in the cases listed under headings 5 and 6) the unit content of the material introduced was also smaller but treatments were repeated over several days or weeks.

I. *Loculated Post-Pneumonectomy Hemothorax.* (See Figs. 1A and 1B.)

The results obtained in the treatment of one of the patients of this group has been previously reported.¹ The description of an additional patient is as follows:

Patient A. L. was a 35-year-old white female. Pulmonary tuberculosis was first noted in 1947. Induction of pneumothorax was subsequently followed by development of pleural effusion. Thoracoplasty was performed in August, 1948. Right pneumonectomy was performed in October, 1948. Postoperatively multiple loculations of fluid were collected with scant yield from aspiration at any site. Seventeen days later 200,000 units of SK (with minimal SD) were injected into each of two areas. During next 24 hours 650 cc. of sanguinous fluid were easily removed.

II. *Post-Traumatic Hemothorax.* (See Figs. 2A and 2B.)

Patient H. F. was a 52-year-old white male. Multiple fractured ribs were sustained, with development of pneumo-hemo-thorax. Blood could not be adequately drained. After 3 weeks, closed thoracotomy was performed. However, even with tube in proper position, drainage was meagre and complete collapse of lung persisted. Three days later 100,000 units of SK (with minimal SD) was introduced through the tube and a second dose injected intercostally. The tube was clamped off to retain SK. Three hours later clamp removed and suction applied. Several hundred cc. (not measured) of fluid were removed by aspiration within a few hours. The lung promptly expanded. Subsequently, when drainage became minimum, the tube was removed. Recovery was uneventful.

III. *Loculated, Post Pneumonic, Empyema, Sterile.* (See Figs. 3A and 3B.)

Patient T. P. was a 40-year-old white male. On nineteenth hospital day of pneumococcal lobar pneumonia, only 50 cc. of thick, greenish purulent fluid could be removed from chest by aspiration. Cultures were sterile. Pleural loculations were evident by roentgenogram. Ten cc. of a preparation containing 100,000 units of SK and 25,000 units of SD were introduced. Twenty-four hours later 465 cc. of thin, blood-tinged, cloudy fluid was removed with ease. Temperature fell to normal and rapid clinical recovery occurred. No further aspirations were necessary.

IV.-1. *Bacterial Empyema.* (See Figs. 4A and 4B.)

Patient W. K. was a 65-year-old white male. After a month of cough and thoracic pain he was admitted to hospital. Evidence of pleural effusion was present. Thoracentesis yielded thick, greenish, foul-smelling pus; anaerobic streptococci were obtained by culture. Open thoracotomy was performed and a drainage tube inserted. An anterior paramediastinal pocket remained undrained. Additional foul-smelling pus was aspirated by direct anterior intercostal approach and 3 cc. of a solution containing 100,000 units of SK and 5400 units of SD, together with 100,000 units of penicillin, was introduced into the pocket. During the ensuing 24 hours about 75 cc. of exudate was aspirated directly. There was some increased drainage through the tube. Recovery was rapid and uneventful.

STREPTOCOCCAL ENZYMATIC DEBRIDEMENT

FIG. 3

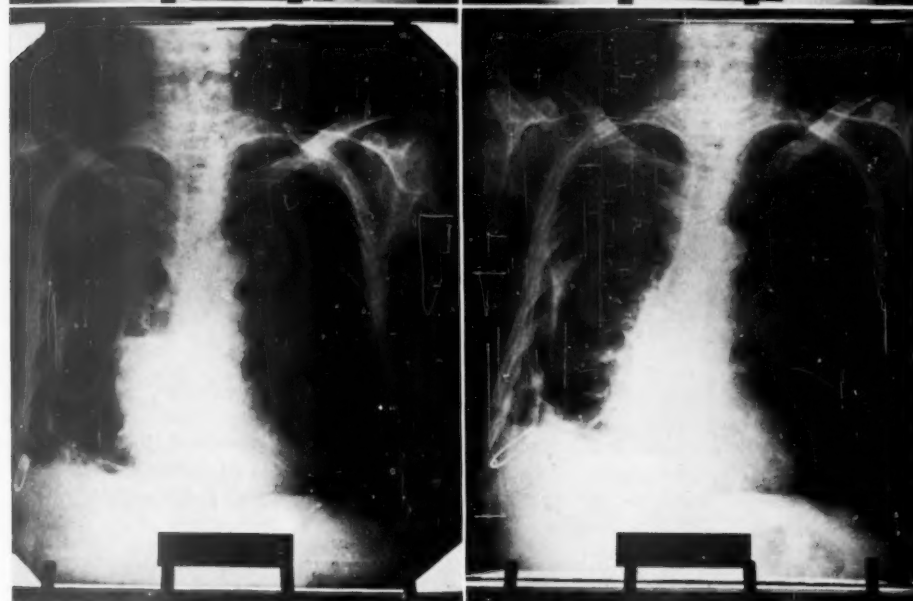
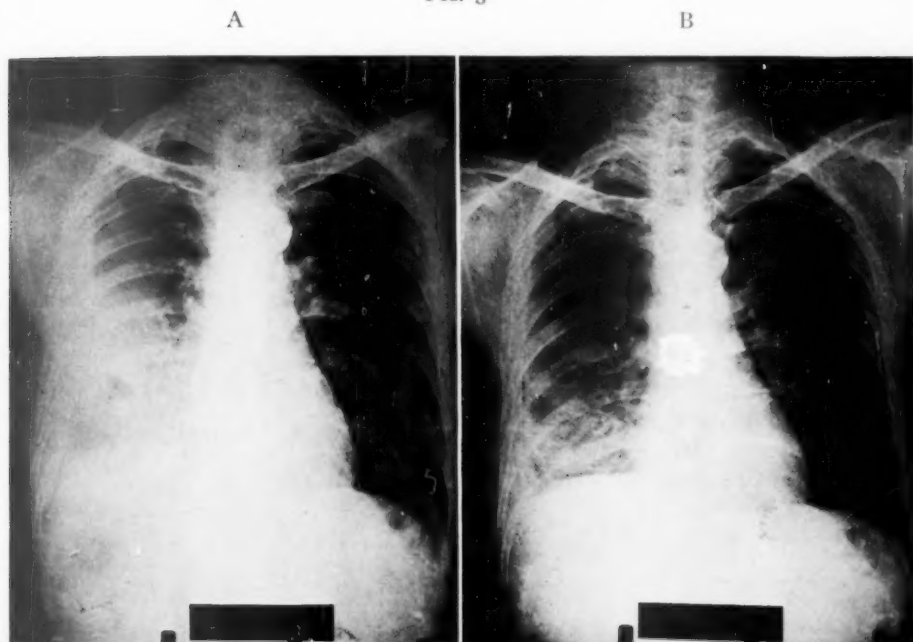


FIG. 4

FIG. 3.—Patient T. P. Postpneumonic, loculated, empyema. (A) Before treatment. Loculated areas present. (B) Twenty-four hours after treatment 465 cc. of fluid removed by aspiration.

FIG. 4.—Patient W. K. Bacterial Empyema (*Anerobic Streptococcus*). (A) Right para-mediastinal pocket of loculated pus with fluid level. (B) Twenty-four hours after treatment, pocket disappeared and did not reform.

IV.-2. *Post-pneumonectomy B. Pyocyaneus Empyema.* (See Figs. 5A and 5B.)

Patient J. H. was a 63-year-old white male. Pneumonectomy, which had been preceded by pneumonotomy 15 months previously, was performed for lung abscess. *B. pyocyaneus*, which had been originally present in the abscess, was also present post-operatively, in the thoracic exudate which loculated. 200,000 units of SK (with minimal SD) was injected; 24 hours later 1100 cc. of sanguinous fluid was aspirated. Loculations

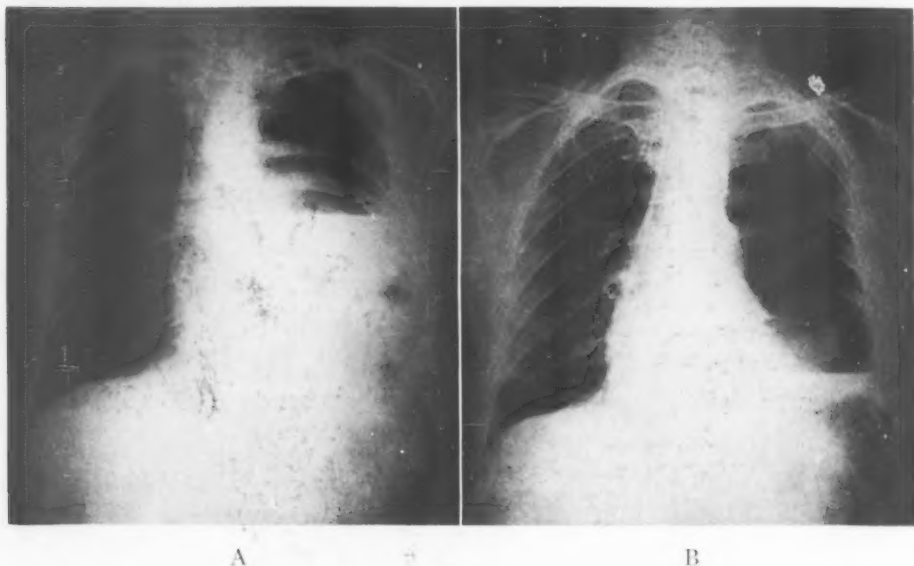


FIG. 5

FIG. 5.—Patient J. H. Bacterial Empyema, Post-pneumonectomy (*B. pyocyaneus*). (A) Fluid levels and loculations present. (B) Twenty-four hours after treatment, 1100 cc. of fluid were removed by aspiration. Shadow over lower portion of left thorax subsequently disappeared.

disappeared but *B. pyocyaneus* remained. Local installations of penicillin, sulfadiazine, streptomycin, parachlorophenol, and urethane failed to affect *B. pyocyaneus*.

The patient then received on alternate days, 7000 to 9000 units of streptodornase (with minimum SK). The colony count of bacteria progressively decreased, permanent sterility occurring after the third treatment. Thoracoplasty was performed successfully three weeks later.

The results obtained in this patient deserve special comment. Since *B. pyocyaneus* does not have primary pathogenic properties for man, its presence in infection is usually that of a secondary invader into areas of disease where damaged tissue or exudate previously existed. In patient J. H., therefore, the removal of the exudate and debris through the application of *streptococcal enzymatic debridement* permitted the antibacterial factors of humoral and cellular resistance of the patient to destroy the organisms. This finding,

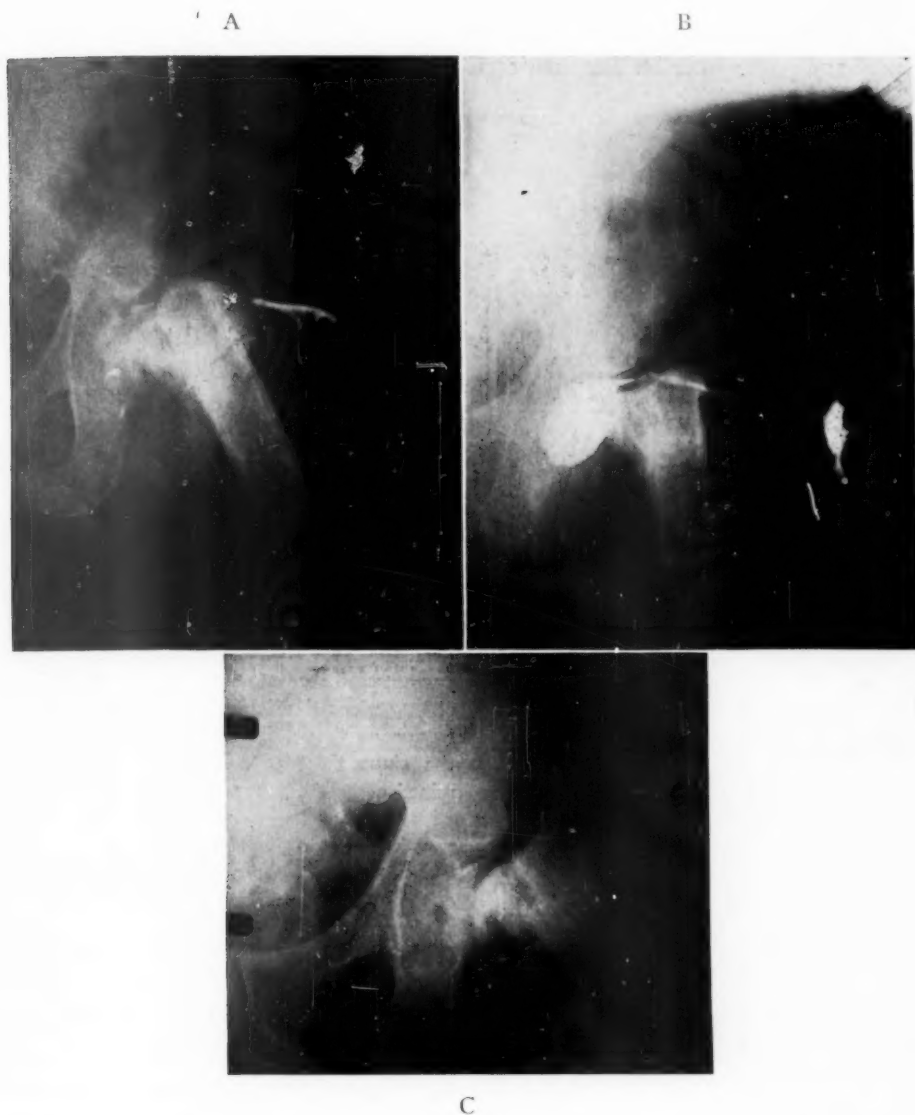


FIG. 6

FIG. 6.—Patient P. C. (A) Effort to introduce Diodrast into sinus tract was ineffectual. The areas of acetabulum, ilium and lateral surface of upper femur appear mottled. (B) After the second treatment, Diodrast was introduced, the shadow of which indicates sinus tract and location of inner pocket of infection in the region of the acetabulum. (C) Treatment terminated; no Diodrast present. The mottling, presumably caused by exudative debris, is considerably reduced. This roentgenogram is interpreted as revealing a part of head of femur fixed in acetabulum, and new bone formation from the inner surface of top of misplaced femur; confirmed at operation.

together with similar ones noted in other patients of our series, indicates that special principles are operative through which either natural immunity against bacteria existing as secondary invaders, or specific acquired immunity against primary pathogenic strains, are capable of gaining access to and destroying the organisms present in chronic infections, following the enzymatic cleaning of the tissues.



B
FIG. 7

FIG. 7.—Patient P. C. (Continued)
(A) Area of ulcerated wound of soft tissue of the thigh. Note wrinkled skin due to brawny edema. (B) After two weeks of treatment the area of wound has been reduced to a small funnel leading to the sinus tract. Smooth appearance of skin is due to the disappearance of edema.

given daily injections of 20,000 units of SK and 4000 units of SD for approximately 10 days.

The effects beginning within 48 hours were as follows: First, the amount of exudate increased, and it was noticeably thinner. The odor disappeared. The brawny edema lessened and finally disappeared. The pain lessened. The catheter was now readily inserted into the acetabular area and the cavity outlined by roentgen rays taken following the introduction of diodrast.

The oblong superficial wound progressively decreased in size, leaving only the sinus tract at the upper angle of the wound.

V.-1. Osteomyelitis with Chronic Draining Sinus Tract and Ulceration of Skin and Soft Tissues. (See Figs. 6A, 6B, 6C, 7A and 7B.)

Patient P. C. was a 50-year-old white male. Intertrochanteric fracture was sustained in March, 1947. A Smith-Peterson nail was inserted; in January, 1948, it was removed. A sinus developed in the lateral aspect of the thigh which drained foul purulent material. In June, 1948, part of the greater trochanter was removed, but sinus drainage continued as before. When first presented for treatment the patient had an oblong ulcerative lesion of the skin and subcutaneous tissue, from the bottom of which the sinus tract extended into an undetermined area in the region of the acetabulum. This situation had persisted unchanged for 6 months. Foul smelling thick pus exuded. On culture *B. proteus*, *B. pyocyaneus*, *Staph. albus*, and other unidentified saprophytic organisms were present. There was a brawny indurated non-pitting edema of the upper half of the thigh. Pain was elicited by palpation, and severe pain resulted from any effort to manipulate the joint.

Lysing enzymatic debridement was begun in December, 1948, by the introduction of concentrate deep into the sinus tract through a small plastic catheter. The patient was

FIG. 8

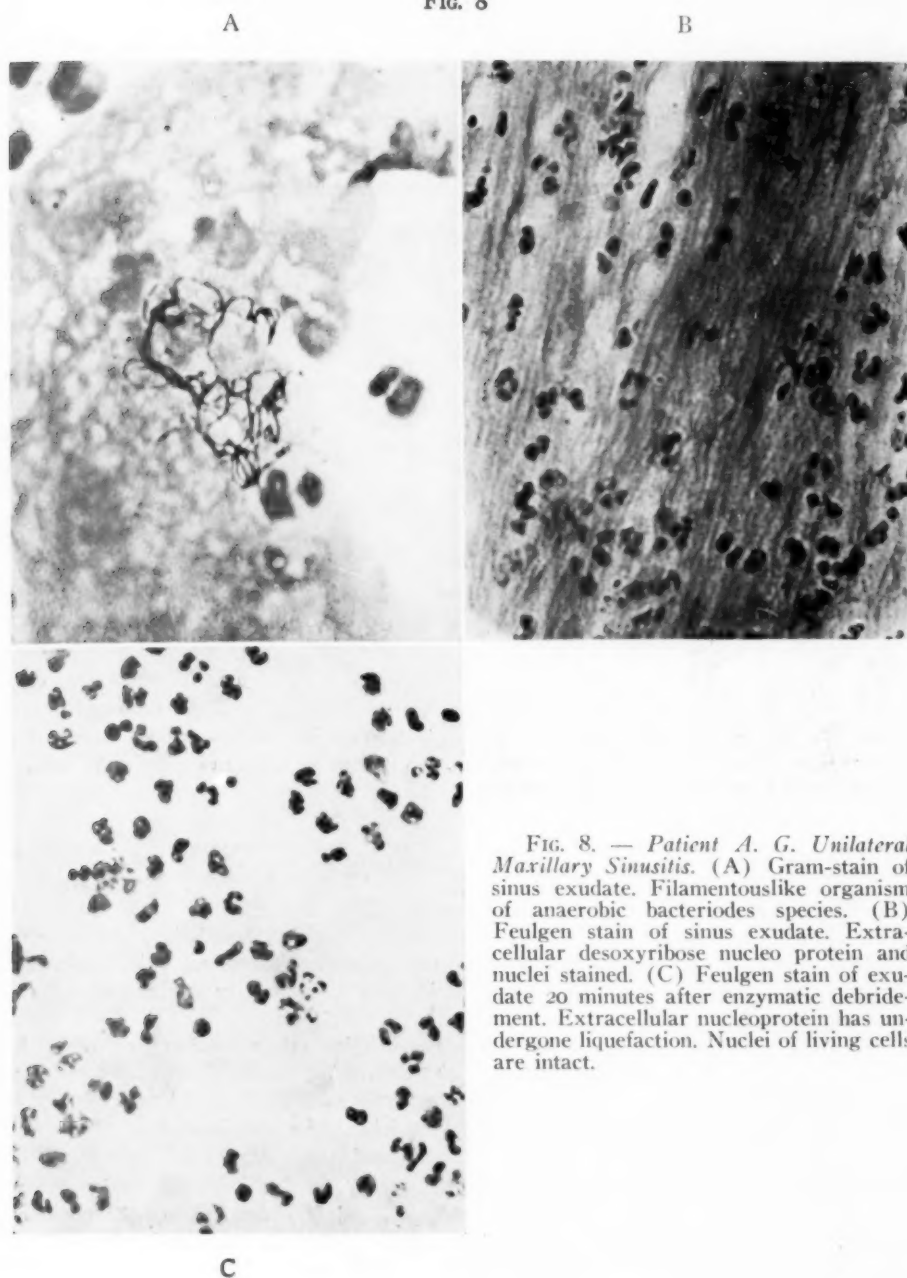


FIG. 8. — Patient A. G. Unilateral Maxillary Sinusitis. (A) Gram-stain of sinus exudate. Filamentouslike organism of anaerobic bacterioides species. (B) Feulgen stain of sinus exudate. Extracellular desoxyribose nucleoprotein and nuclei stained. (C) Feulgen stain of exudate 20 minutes after enzymatic debridement. Extracellular nucleoprotein has undergone liquefaction. Nuclei of living cells are intact.

After 5 weeks of additional intermittent therapy it was possible to demonstrate a piece of the head of the femur as a sequestrum in the acetabulum. The pain completely disappeared and the patient could sit up in bed and also extend his foot to the floor.

In February, 1949, operation was performed, the dead portion of the head of the femur, devoid of exudative coating, was removed, and the incision completely closed. The patient at present continues in a plaster cast, but there is no drainage from the site of the original sinus tract.

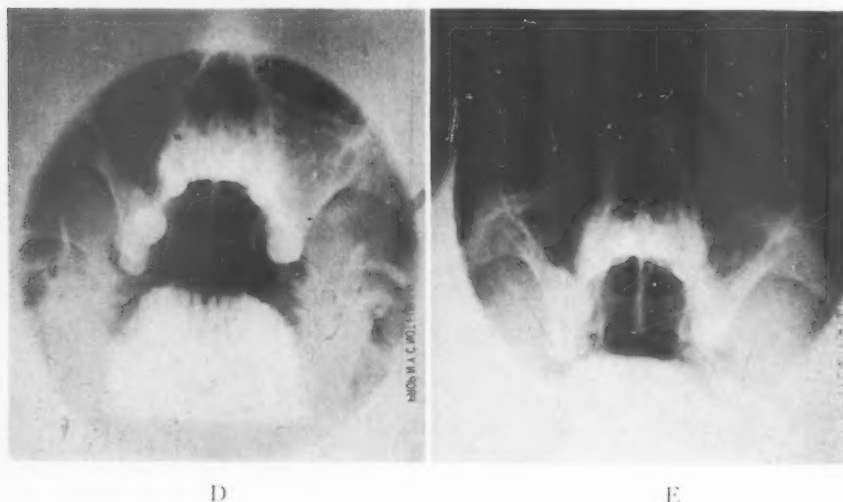


FIG. 8

FIG. 8. (Continued) (D) Roentgen ray photograph showing clouding of left maxillary sinus. (E) Roentgen ray photograph indicating degree of clearing of left maxillary sinus ten days after therapy.

V.-2. *Unilateral Maxillary Sinusitis.* (See Figs. 8A, 8B, 8C, 8D and 8E.)

Patient A. G. was a 42-year-old white male. Chronic left maxillary sinusitis had been present for 3 years. Onset of acute exacerbation began 10 days before admission to hospital. No spontaneous drainage had occurred. Characteristic local pain, tenderness on pressure, and fullness were present. Considerable inflammatory swelling of natural ostia was present.

A straight trocar was inserted through the inferior meatus and 0.5 cc. of thick, foul-smelling pus was withdrawn by forced suction. After the injection of 0.5 cc. of a concentrate containing 500 units of SK and 1000 units of SD, the rapid aspiration of 5 cc. of thin purulent material was accomplished quickly. An additional dose of concentrate was instilled to complete the debridement and the trocar was then removed. The patient was also receiving penicillin intramuscularly.

The accompanying photographs (Figs. 8A, 8B, and 8C) demonstrate the etiologic agent and the cytologic and histologic changes that followed the liquefaction of the sedimented nucleoprotein. All subsequent cultures were sterile. The odor of the purulent exudate disappeared.

The patient obtained considerable relief from symptoms. The edema of the natural ostia subsided and drainage through it occurred spontaneously. The patient appeared well 8 weeks after the debridement. (See Figs. 8D, and 8E.)

A



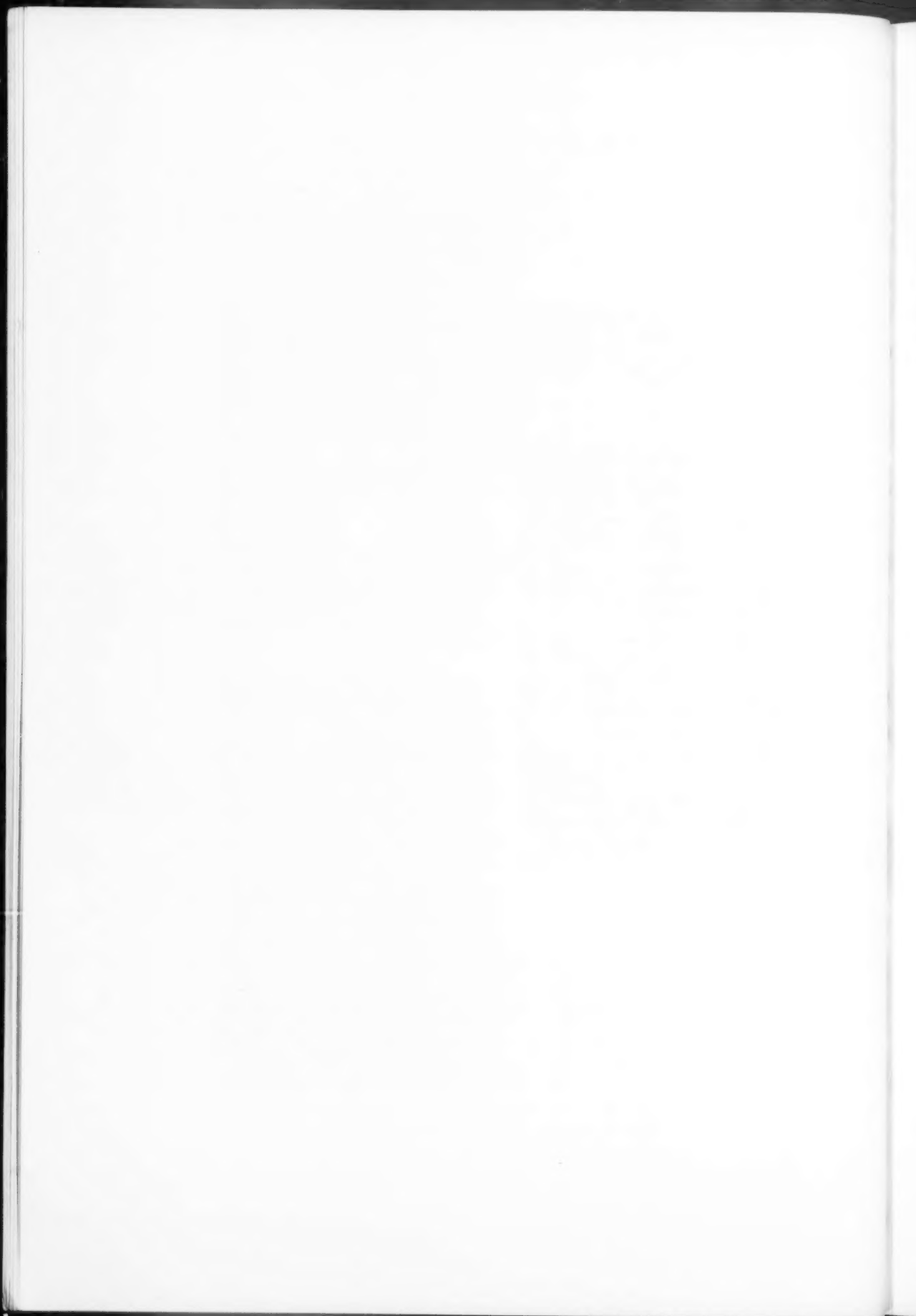
B



C



FIG. 9.—(A) Appearance of ulcerative lesion before treatment. (B) Appearance after three weeks of intermittent treatment to upper area only. (C) Appearance after ten days of intermittent therapy applied only to upper advancing portion. Exudate has ceased to reform and epithelialization has covered most of upper area.



VI. *Chronic Ulcerative Lesion of Leg (etiology unknown)*. (See Figs. 9A, 9B, and 9C.)

Patient R. B. was a 38-year-old colored male. Ulceration of skin over right tibia began with a small blister 6 months prior to admission. The denuding process gradually extended until it involved about one-third of the area between knee and ankle. Biopsies revealed only chronic inflammation. Antibiotic therapy was unsuccessful. The advancing edge of the lesion which extended upward, was tender to touch, and was covered with exudate.

A few cc. of concentrate rich in SK and SD were applied to the area of advancing lesion and the solution was held in place by a covering of rubber sheeting sealed with rubber cement for as many hours as possible. The treatments were repeated in this same site every 2 to 3 days for 14 days. The photographs (Figs. 9A, 9B, and 9C) demonstrate the epithelialization and regrowth of skin that occurred in 3 weeks time. No further advancement of the lesion occurred. The larger areas of the lesion were treated by skin grafting.

DISCUSSION AND SUMMARY

Against the background of previous studies of the fibrinolytic and pus-liquefying enzymatic systems elaborated by hemolytic streptococci,¹⁻⁷ the results recorded in this article demonstrate the usefulness and rapid effectiveness of the treatment of selected types of diseased states with streptokinase and streptodornase.

In patients in whom the presence of extravascular clotted or loculated hemorrhage without infection was the principal difficulty, the rapid lysis of fibrinous strands and coagulum was accomplished primarily through the action of the streptokinase system. In cases of this type the possible necessity of surgical decortication appears to have been obviated by the effectiveness of the enzymatic decortication.

When infection has been present, the mechanical effects caused by loculation were found to be complicated by the presence of a coating of tissue surfaces with the desoxyribose nucleoprotein of purulent exudates plus fibrin. And, in addition, viable organisms were present to be a constant stimulus to the formation of more exudation through which chronic infection was maintained.

The use of the streptococcal concentrates containing both streptokinase and streptodornase in eradicating the loculations or exudations of chronic infections has been referred to as *streptococcal enzymatic debridement*. Where effective application has been accomplished the following changes have been observed: a marked thinning of the exudate, an outpouring of viable leukocytes, decrease in the number of or disappearance of the locally infecting bacteria, subsequent decrease or disappearance of exudate, and rapid regrowth of tissues and epithelium.

The results strongly suggest that the effective clearing of the site of infection through enzymatic action renders the area permeable to humoral and cellular forces of both natural and specifically acquired immunity, or to circulating antibiotics, that are capable of eliminating the organisms.

The rapid rate of regeneration of the soft tissues and epithelium following

debridement has also been observed in many instances which implies that an unusual effect is exerted on fixed tissues.

Many factors and elements of this study are still in the developmental stage. Determinations of optimal dosage, frequency of administration, methods of application which bear a relation to nature, extent, and site of the disease are required before maximal effective use, as well as limitations and contraindications, can be comprehensively defined. Such additional studies are now in progress.

The authors wish to express their appreciation to the Attending Surgeons of all the Surgical Divisions of Bellevue Hospital for their constant co-operation and advice, and in particular to Dr. John H. Mulholland, Director of the Third Surgical Division.

Subsequent articles on the results obtained in these series of studies will, through co-authorship with our surgical associates, include detailed reports of factors pertinent to a comprehensive surgical analysis of each of the groups of patients that have been treated.

BIBLIOGRAPHY

- ¹ Tillett, W. S., and S. Sherry: *J. Clin. Investigation*, **28**: 173, 1949.
- ² Sherry, S., W. S. Tillett and L. R. Christensen: *Proc. Soc. Exp. Biol. & Med.*, **68**: 179, 1948.
- ³ Tillett, W. S., S. Sherry and L. R. Christensen: *Proc. Soc. Exp. Biol. & Med.*, **68**: 184, 1948.
- ⁴ Christensen, L. R.: *J. Clin. Investigation*, **28**: 163, 1949.
- ⁵ Sherry, S., A. Johnson and W. S. Tillett. (In press.)
- ⁶ Tillett, W. S., and R. L. Garner: *J. Exper. Med.*, **58**: 485, 1933.
- ⁷ Tillett, W. S., S. Sherry, L. R. Christensen, A. Johnson and G. Hazlehurst: The findings reported in this article were, in part, presented at a Meeting of the Association of American Physicians held in Atlantic City, N. J., May 3, 1949.

POSTURAL CHANGES IN THE CIRCULATION OF SURGICAL PATIENTS AS STUDIED BY A NEW METHOD FOR RECORDING THE ARTERIAL BLOOD PRESSURE AND PRESSURE PULSE*

LYSLE H. PETERSON, KENNETH F. EATHER AND ROBERT D. DRIPPS

PHILADELPHIA, PA.

FROM THE DEPARTMENT OF ANESTHESIOLOGY, HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, THE HARRISON DEPARTMENT OF SURGICAL RESEARCH AND THE DEPARTMENT OF PHYSIOLOGY, UNIVERSITY OF PENNSYLVANIA SCHOOL OF MEDICINE

MANY ANALYSES have been made of the circulatory response of man to the assumption of the erect position. The changes in cardiac output, arterial blood pressure and pulse rate which occur have been recorded in normal individuals and in patients under a variety of conditions. Measurements of the increase in volume of the lower extremities in the head-up position have been reported by Asmussen and his co-workers.¹ They concluded that approximately 550 cc. of blood could be pooled immediately in the legs as soon as the upright position was assumed and that another 400 cc. might be lost from the circulation as a result of increased hydrostatic pressure in the veins and filtration of blood through the capillary walls. The capacity of the legs to hold blood is unquestionably established. The effects of postural changes on the circulation, however, have not received the attention they deserve in routine surgical practice. It is our hope in this paper to illustrate certain circulatory alterations, beneficial as well as detrimental, which we have noted in patients moved into and out of the various positions, and to emphasize again the implications inherent in these changes.

One of the major reasons for the general lack of recognition of these well established postural effects has been the difficulty of making accurate circulatory measurements under clinical conditions. The Riva-Rocci method of estimating blood pressure has many deficiencies.^{2, 3} Intra-arterial recording of blood pressure has not been popular because of the problems of arterial puncture, of maintaining a rigid needle in a vessel, and of having to await the development of photographic paper before data became available. The recent introduction of a compact, mobile and flexible apparatus for the measurement of arterial pressure and pressure pulse contours has made it possible to record in the operating room circulatory changes of interest to surgeons and anesthesiologists.^{4, 5}

Although this new method does involve arterial puncture with a 22-gauge needle, it possesses several distinct advantages. Instead of the needle, a small plastic catheter is left in the artery and can remain in place for hours without complication. The catheter is made from a synthetic polyvinyl resin. As re-

* Supported in part by a grant from the Office of Naval Research to Dr. H. C. Bazett. Submitted for publication May, 1948.

ceived from the manufacturer the tubing is quite flexible and elastic. Flexibility is desirable. The elasticity must be reduced to such a degree that it does not introduce a damping factor in the cardiovascular pressure ranges. This is accomplished by heating the plastic in an oven for 72 hours at 110°C . Since the plastic is thermosetting the tubing can at the same time be drawn out and set to any desirable length and diameter. Our catheters are drawn out to an inside diameter of about 0.2 mm. The catheterization device consists of a hollow steel plunger ground to fit a standard 1 cc. tuberculin syringe. At one end is soldered a nipple upon which the catheter fits. The other end is fitted to a capacitance manometer, since its small volume displacement permits recording through small catheters.⁶ The syringe barrel is filled with sterile physiologic saline. The arterial puncture is made, the plunger is then projected downward, thus injecting the catheter into the vessel. The needle is then withdrawn. Before catheterization the manometric system is flushed with an anti-coagulant solution. This solution is contained in a pressure reservoir which is attached via a side tube and needle valve to the manometer. During the recording a slight leak (1.0 cc. or less per hour) of solution occurs. This insures that changes in blood pressure will not cause clotting.

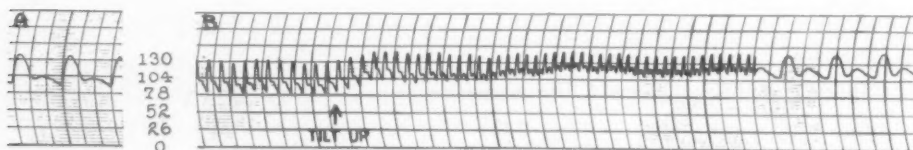


FIG. 1.—Effect of tilting a normal, healthy, 32-year-old male, from horizontal to 70° head-up position, on a reclining tilt table. When corrections are made for the hydrostatic differences it is seen that the pressure in the carotid sinus falls, while the pressure in the aorta remains only slightly altered and the brachial pressure at the point of measurement, as seen, rises. At the slow paper speed the vertical lines equal 1.0 second, and at the faster speed the vertical lines equal 0.2 second. "A" is the faster paper speed of the pre-tilt pulse curve.

In place of photographic recording, an ink-writer is used, the record therefore being immediately available to the observer. Recording can be carried out in any position and with little or no disturbance of the surgical routine. The recording unit can be moved as far as 20 feet from the patient with only three small flexible leads as the connection. Despite the apparent complexity of the apparatus it can be managed by a single individual and can be shifted from patient to patient merely by changing catheters. It has proved of great value in the operating room both as an experimental unit and as a measure of circulatory adequacy during operations.

RESULTS

As an introduction to the vascular changes to be presented it seemed appropriate to outline the effects of gravity on the circulation of normal man

tilted from the supine to the head-up position. At the point of measurement these consist of the following: a decrease in systolic blood pressure; maintenance or elevation of diastolic blood pressure; a decrease in stroke volume of the heart and an increase in the heart rate.* These alterations are illustrated in Figure 1, which represents two sets of tracings obtained with the apparatus just described. Examination of the pressure pulse contours during the tilt reveals a change in their configuration. The height of the systolic rise has decreased, and the peak is more rounded. These changes are interpreted to indicate primarily a decrease in stroke volume. Changes in the systolic and diastolic levels and in the pulse rate are evident in the record. These are essentially normal responses and represent a successful compensatory reaction to the pooling of blood as the result of gravity.

The explanation for these changes can be simplified. At the time of the tilt, systolic pressure falls in the carotid sinuses. A decrease in pressure in these regions leads to: (1) constriction of those vessels innervated by the thoracolumbar sympathetic outflow; and (2) an increase in heart rate. Because of these two changes, diastolic pressure is either maintained or tends to rise. As the result of pooling of blood peripherally, venous return decreases and hence stroke volume declines.

In approximately 8 to 10 per cent of normal individuals compensation fails and circulatory collapse results from a tilt into the head-up position.⁷ The incidence of circulatory inadequacy in response to postural changes, furthermore, can be greatly increased by such factors as narcotics, heat, sympathectomy (either by drugs or surgical section), or any other condition which causes dilatation of vessels in the skin and muscles and hence permits greater accumulation of blood under the influence of gravity. For example, 44 per cent of a series of normal subjects exhibited profound hypotension when tilted 30 minutes after the intramuscular administration of 15 mg. of morphine sulfate.⁷

It seemed probable that the anesthetized surgical patient would be equally susceptible to postural changes, if his compensatory mechanisms were either depressed (sedatives) or abolished (spinal or deep general anesthesia). Illustrations of this susceptibility follow.

1. *Deleterious effects of changing from the lithotomy position to the horizontal.* A number of surgical procedures are carried out with the legs elevated. It is not infrequent for the anesthesiologist to report a normal blood pressure and pulse rate just prior to the conclusion of such operations, only to note a sharp decrease in blood pressure when the lower extremities are returned to the horizontal.⁸ This sequence of events tends to be more common after longer operations where blood loss may have been excessive or where, because of prolonged elevation, there may have been anoxic changes in the

* If the manometer is not at the level of the heart, correction for any hydrostatic difference in pressure must be made.

vessels of the legs, predisposing to vasodilatation and increased permeability. Such hypotension may be severe, and being unexpected, may find the surgical team ill-prepared. We have noted these changes after all types of anesthesia, and in all age groups above the second decade. In a recent series of vaginal procedures performed in the lithotomy position 14 of the 31 patients showed a decrease in blood pressure when they were returned to the horizontal position. The drop in pressure ranged from 25 to 60 mm. Hg. systolic. Such changes have also been noted after transurethral resection, perineal prostatectomy, abdomino-perineal resection and other operations performed with the patients' legs elevated. An illustrative case will be presented.

Case 1.—H. R., 71 years of age, suffered benign prostatic hypertrophy. Examination revealed a blood pressure of 160/74, moderate cerebral arteriosclerosis and slight cardiac enlargement. A perineal prostatectomy was performed, with 12 cc. of 1 to 1500 Nupercaine as the spinal anesthetic agent. No pressor drug was administered. Blood pressure, before injection of the anesthetic, was 154/78. Two hours later, just before the legs were brought down out of the exaggerated lithotomy position, the blood

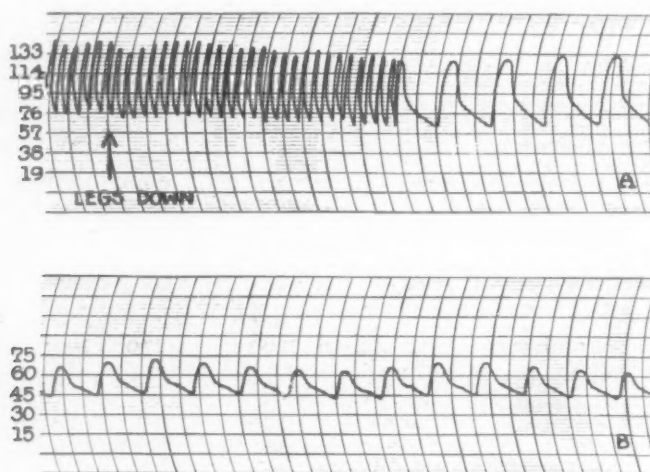


FIG. 2.—(A.) Pressure record at time of leg change (see text). (B.) Two minutes later.

This figure has been retraced for photography. Ink used for recording at the time these records were taken was green on red background paper.

pressure was 130/70. The operative course had been very smooth; 300 cc. of whole blood and 300 cc. of 5 per cent glucose in water had been given intravenously during the procedure. As the patient's legs were returned to the horizontal position the blood pressure began to fall and during the next two minutes reached 70/45 (Fig. 2). It is evident in the tracing that the cardiac output has decreased significantly as the result of the change in position.

This sequence of events was similar in some respects to that described during tilting. The hypotension in all probability resulted from the return of blood to the legs as these vessels became, in a sense, more available in the horizontal position. In effect, the patient

POSTURAL CHANGES IN CIRCULATION

suffered from a sudden hemorrhage of about 500 cc. of blood, and circulatory inadequacy resulted, because compensatory reactions were depressed or abolished by preoperative medication, spinal anesthesia and blood loss.

Surgeons and anesthetists must anticipate such changes and be prepared either to prevent them, or to treat them once they have developed. Prophylactically, one can use tight pressure bandages from toes to groin. Therapeutically, "pressor" drugs are frequently recommended. We propose a

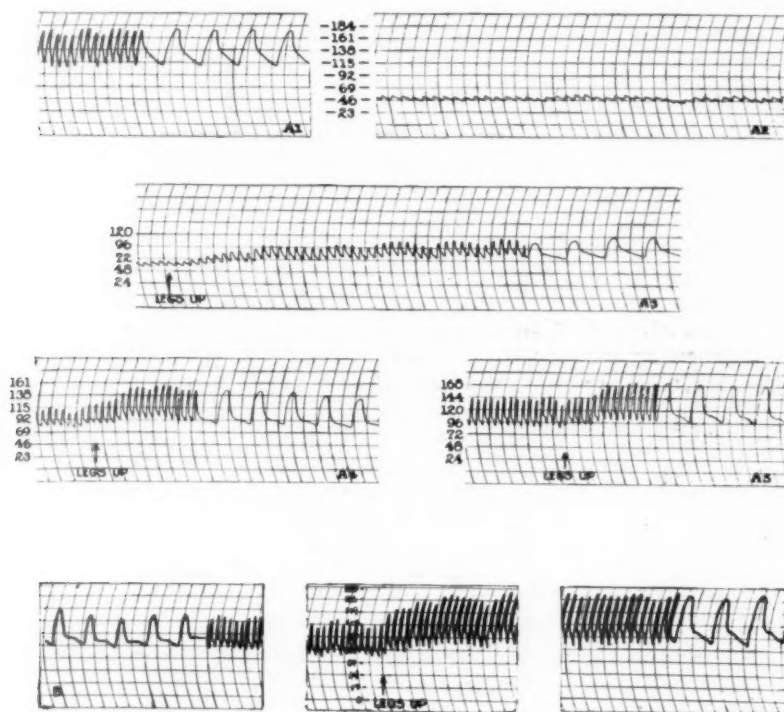


FIG. 3.—A₁—Brachial intra-arterial pressure pulse from patient C. W. (see text) prior to spinal anesthesia. This patient had a history of hypertension.

A₂—Four minutes after the administration of spinal anesthesia (no pressor drug).

A₃—Effect of raising legs at the hip without altering the position of the trunk. This elevation was maintained for about two minutes, then the legs were again lowered. Methedrine Sulphate (5.0 mg.) had been given three minutes previously.

A₄—Repetition of procedure (A₃) five minutes later.

A₅—Repetition of procedure 15 minutes after A₃.

B—Patient's (S.G.) brachial arterial pressure before and after the legs have been raised as in section A. (This record has been traced for photographic purpose.)

method which is more physiologic, more rapid in action, and which, on occasions, has raised blood pressure when sympathomimetic drugs have failed. It represents essentially a reversal of the changes just noted.

2. *Beneficial effects of the lithotomy position.* On the basis of his esti-

mates of the vascular capacity of the legs, Asmussen made the statement that "circulatory insufficiency due to a peripheral dilation of the vessels or to a loss of blood can be counteracted by an elevation of the lower extremities."¹ He termed this an "autotransfusion." We have been able to confirm his suggestions and believe that such a manœuvre, obviously more physiologic an approach than injections of drugs, may be of therapeutic value when blood pressure has decreased for any reason. Several illustrations will be given of the utility of elevation of the legs.

Case 2.—C. W., male, 62 years of age, had a tender mass in the left upper quadrant. Blood pressure was 160/115, pulse rate 82, Hb. 60 per 100 cc. This patient had had acute left flank pain and had been vomiting for 30 hours prior to admission. On admission he was suffering from marked abdominal distention. Differential diagnosis was uncertain. With chemotherapy, intestinal suction-drainage and parenteral fluids his acute symptoms subsided. Four days later a retrograde pyelogram was planned. Five milligrams of 1 to 200 Nupercaine in 1 cc. of 10 per cent glucose was used for the production of spinal anesthesia. No pressor drug was given. Within the next five minutes, as the sensory level reached D₉, the blood pressure fell to the point where it was imperceptible by sphygmomanometry. Intra-arterial pressure recording, however, indicated a pressure of 58/46 (Fig. 3A₂). Five milligrams of Methedrine were injected intravenously with no effect. Previous experience with this sympathomimetic amine has indicated that if a pressor response is to be elicited it will be noted within a few minutes of the intravenous injection. One hundred per cent oxygen was administered. It was then decided to attempt autotransfusion. The legs were elevated for two minutes on each of three occasions. As can be seen in Figure 3A, the first of such elevations raised the pressure to 113/80, the second, three minutes later, to 143/83 and the third, three minutes later, to 166/97. Each time the legs were raised blood pressure rose and, interestingly enough, the pressure did not fall when the legs were placed flat again. Successive attempts were obviously increasingly helpful.

Case 3.—S. G., male, 66 years of age, with benign prostatic hypertrophy; had a blood pressure of 160/72. Physical examination was otherwise essentially normal for one of his age. He was scheduled for a perineal prostatectomy. Ten cc. of 1 to 1500 Nupercaine solution were injected into the subarachnoid space at 1:10 P.M. No pressor drug was administered prior to the anesthesia. The blood pressure fell gradually to 96/58, with a sensory level of anesthesia at D₇. Elevation of the legs at 1:18 P.M. resulted in a rise in blood pressure to 145/82 and an apparent increase in cardiac output (Fig. 3b).

This experience has been repeated many times. As already stated, elevation of the legs is more physiologic than is the administration of vasoconstrictor drugs. It also acts instantly, whereas, in our experience, several minutes may be required for a pressor drug to exert its effect even though it be injected intravenously. It is superior in our opinion to the Trendelenburg position because it improves the circulation without embarrassing respiration. In the Trendelenburg position respiratory work is increased considerably since each contraction of the intercostal and diaphragmatic muscles must not only expand the thoracic cage, but must at the same time push against the contents of the abdominal cavity which have moved down as the result of gravity.

Elevation of the legs is most effective in raising the blood pressure when

hypotension results from a decreased peripheral resistance. If the fall in blood pressure is primarily the result of a diminished stroke volume, due presumably to splanchnic pooling with constriction of arterioles elsewhere, postural methods may be much less successful. In such instances "pressor" drugs are often likewise ineffective. Indication of the type of hemodynamic alteration primarily responsible for the low blood pressure may be obtained from the records we have described. One merely analyzes the pressure pulse contour and distinguishes between the wave indicative primarily of a decreased stroke volume (see above) and that indicative primarily of a decreased peripheral resistance.⁴ This latter is characterized by little change in the height of the systolic rise, and a sharp increase in the rate of fall of the diastolic limb. In some instances the incisura may reach diastolic levels.

SUMMARY

With a new method of recording intra-arterial pressure and pressure pulse waves we have been able to observe a number of postural changes in the circulation which are of practical significance to the surgical patient. Marked hypotension may follow return of the patient from the lithotomy to the horizontal position. Yet paradoxically this pooling of blood in the lower extremities which under the circumstances just noted, is so harmful, may be turned to the patient's advantage. Thus, in conditions of low blood pressure primarily caused by vasodilation, elevation of the legs, *i.e.*, autotransfusion, may be of great help. We have seen such a measure correct a severe hypotension which has resisted the intravenous administration of pressor drugs. The method we propose is more physiologic than is drug therapy, and it acts more quickly.

We recommend the use of this new apparatus for measuring blood pressure to surgeons in the belief that many other important vascular abnormalities may be recognized and studied. It has proved invaluable in minimizing the errors inherent in the indirect methods of measuring blood pressure. It does not interfere with the routine in an operating room. It offers knowledge of the cardio-vascular status of the patient from beat to beat and permits logical therapeutic efforts to be instituted promptly.

BIBLIOGRAPHY

- ¹ Asmussen, E., E. H. Christensen and M. Nielsen: The Regulation of Circulation in Different Postures. *Surgery*, **8**: 604, 1940.
- ² Bazett, H. C., and L. B. Laplace: Studies on the Indirect Measurement of Blood Pressure. *Am. J. Physiol.*, **103**: 48, 1933.
- ³ Ragan, C., and J. Bordley: The Accuracy of Clinical Measurements of Arterial Blood Pressure. *Bull. Johns Hopkins Hosp.*, **69**: 504, 1941.
- ⁴ Peterson, L. H., R. D. Dripps and G. C. Risman: A Method for Recording the Arterial Pressure Pulse and Blood Pressure in Man. *Am. Heart J.*, **37**: 771, 1949.
- ⁵ Eather, K. F., L. H. Peterson and R. D. Dripps: Studies of the Circulation of Anesthetized Patients by a New Method for Recording Arterial Pressure and Pressure Pulse Contours. *Anesthesiol.*, **10**: 125, 1949.

- ⁶ Lilly, J. C., V. Legallais and R. Cherry: A Variable Capacity for Measurements of Pressure and Mechanical Displacements: A Theoretical Analysis and Its Experimental Evaluation. *J. Applied Physics*, **18**: 613, 1947.
- ⁷ Drew, J. H., R. D. Dripps and J. H. Comroe, Jr.: The Effect of Morphine upon the Circulation of Man and Upon the Circulatory and Respiratory Responses to Tilting. *Anesthesiology*, **7**: 44-61 (Jan.) 1946.
- ⁸ Slocum, H. C., E. A. Hoefflich and C. R. Allen: Circulatory and Respiratory Distress from Extreme Positions on the Operating Table. *Surg. Gynec. and Obstet.*, **84**: 1051-1058 (June) 1947.

THE EFFECTS OF HEMOCONCENTRATION ON THE ULCER DIATHESIS*

WITH SPECIAL REFERENCE TO THE EMPLOYMENT OF GASTRECTOMY
IN THE SURGICAL TREATMENT FOR POLYCYTHEMIA VERA

IVAN D. BARONOFSKY, M.D., DAVID STATE, M.D.,
STANLEY R. FRIESEN, M.D., MINNIE FINN, B.A.

AND

OWEN H. WANGENSTEEN, M.D.

MINNEAPOLIS, MINN.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF MINNESOTA

THE ASSOCIATION of gastro-intestinal symptoms and polycythemia vera has frequently been noted. Weber and Watson³⁴ in 1905 described a case of gastric ulcer associated with polycythemia. Since then other cases of associated peptic ulcer and polycythemia have been reported (Bing,⁶ Schneider,²⁷ Wilbur and Ochsner,³⁵ Boyd⁸). A relative polycythemia in cases of peptic ulcer has been found by some authors (Tuchfield³³).

Wood and Blalock³⁶ in 1941 reported on the effects of uncomplicated hemoconcentration. They noted that in some of their animals, particularly those ill due to the effects of concentrating the blood, acute peptic ulcers were present at postmortem. More recently in this laboratory it has been shown that Curling's ulcer, associated with burns, may in part be due to hemoconcentration.^{12, 13}

It is the purpose of this paper to present the results of two series of experiments dealing with the role of hemoconcentration in peptic ulcer formation and abatement. It is also intended to discuss briefly the possible role of a direct surgical attack on polycythemia vera.

METHOD

Two series of experiments were carried out. In one, hemoconcentration was produced by daily plasmaphoresis and the replacement of the volume of plasma with an equal volume of cells from a compatible animal (Series I). In the other, hemoconcentration was produced by the subcutaneous injection of large doses of hypertonic salt solution (25 cc. per Kg. of 25 per cent NaCl). It has been shown that the hemoconcentration thus produced is the result of the displacement of water from the intravascular system to the site of the injection in the subcutaneous space.

Healthy mature dogs were used in this experiment. Blood studies were carried out in all dogs, three determinations before injection for the average

* The researches upon which this study is based were supported by a grant from the United States Public Health Service (Grant No. RG 1028 (C)), the Augustus L. Searle Fund for Surgical Research and the Graduate School. Submitted for publication March, 1949.

of normal values, and serial determinations after injection. The studies consisted of hemoglobin (alkaline hematin method), hematocrit (Wintrobe), R.B.C. count, specific gravity of whole blood and plasma (copper sulfate method), plasma chlorides and B.U.N.

At arbitrary times with or without hemoconcentration being achieved, some of the dogs received histamine-in-beeswax (30 mg. histamine base) intramuscularly. Arbitrary times for beginning the injections were used because some of the animals in both experiments failed to develop any significant hemocon-

TABLE I.—*Dogs with Hemoconcentration Produced by Plasmaphoresis and Red Cell Replacement Accompanied by Administration of Histamine-in-Beeswax (30 mgm. Base).*

Dog No.	Wt. (lbs.)	Length of exp. (days)	Range of daily plasma removal (cc.)	Range of red cell replacement (cc.)	Hemo-globin before sacrifice (Gm./100 cc.)	Hema-tocrit before sacrifice (Win-trobe)	(RBC) Before sacrifice Millions/ Cu. mm.	No. of injections histamine-in-beeswax	G. I. tract findings
1	29.5	7	200-250	200-250	21.9	65.5	10.15	3	Multiple bleeding, gastric and duodenal erosions, small antral ulcer.
2	34.0	16	100-200	100-225	18.1	58	8.07	2	Multiple bleeding, antral ulcers, marked duodenal bleeding from erosions.
3	33.25	14	100-210	100-225	18.7	57	8.64	3	Antral ulcer and marked bleeding from duodenum, fundus and antrum.
4	40.75	4	200	200-225	21.3	63	8.41	2	Duodenal ulcer, bleeding fundus, antral and duodenal erosions.
5	29.0	8	100-225	100-225	21.3	51.0	8.86	0	Died; distemper and pneumonia.
6	20.75	6	100	100	9.3	27	3.47	0	Died; distemper.
7	28.5	5	100-200	100-200	14.8	44	7.02	2	Normal stomach and duodenum.
8	25.25	6	100-110	100	16.2	47	7.31	3	Normal stomach and duodenum.

centration. These, therefore, could be used as controls in addition. In Series II, the beeswax mixture was first injected 30 minutes prior to the injection of the hypertonic salt solution.

It is to be noted that all these experiments were carried out under aseptic conditions. Recently, it has been shown in the excellent review by Harkins¹⁹ that infection may play a part in the production of Curling's ulcer in burns. The dogs' food was not restricted, dried kibbles plus re-enforcing vitamins being given. The fluids allowed by mouth were 300 cc. daily.

EXPERIMENTS

A total of 32 dogs were used in the entire experiment. In Series I, eight dogs were used and 24 in Series II. Eighteen dogs of Series II were injected with histamine-in-beeswax mixture, six were not.

RESULTS

The results of these experiments are summarized in Tables I, II, and III. In the plasmaphoresis red cell replacement series of experiments (Table I), the four animals in which hemoconcentration, as determined by the hematocrit (above 57), was achieved, had ulcers on postmortem examination. The remaining four in which hemoconcentration was not obtained had no gastro-intestinal pathology. The same results were observed in the hypertonic salt experiments. (Tables II and III). Thus, in all experiments when hemoconcentration was achieved and histamine-in-beeswax mixture administered, ulcers or erosions

TABLE II.—*Dogs Receiving Subcutaneous Injection of 25 Per Cent Sodium Chloride Solution Accompanied by Administration of Histamine-in-Beeswax (30 mgm. Base).*

Dog No.	Wt. in Kg.	Amt. NaCl in cc.	No. of histamine injections	Hematocrit change (Initial-Final)	Findings in G. I. tract	Remarks
2	12	120	1	51-60	Congestion; many gastric bleeding points.	Sacrificed 14 hours, hematemesis.
3	10	100	3	48-59	Congestion; small bleeding duodenal and antral ulcers.	Died 3rd day.
4	23	230	3	46-48	Negative stomach and duodenum.	Sacrificed 3rd day.
5	9	90	1	44-53	Congestion; few pyloric bleeding points.	Died 12 hours.
6	7	70	2	43-53	Congestion; bleeding pyloric ulcer.	Died 48 hours.
7	9	90	2	49-48	Negative.	Sacrificed 48 hours.
8	8	80	1	46-49	Congestion; pyloric ulcer.	Sacrificed 24 hours.
9	8.5	85	1	44-45	Negative.	Sacrificed 24 hours.
10	10	100	1	37-50	Congestion; antral ulcer.	Sacrificed 24 hours.
11	9	90	1	43-43	Negative.	Sacrificed 24 hours.
12	13	140	1	45-62	Congestion; bleeding gastric erosion; petechial bleeding points.	Died in 6 hours, irrational, hyperthermia.
13	15	160	1	42-56	Congestion; antral bleeding points.	Sacrificed in 6 hours, irrational, hyperthermia.
14	10	100	1	42-43	Negative stomach and duodenum.	Died 24 hours, aspiration pneumonia.
15	11	110	1	42-51	Congestion; bleeding pyloric ulcer; many bleeding points.	Sacrificed 24 hours.
16	9	90	3	41-35	Negative.	Sacrificed 3rd day.
17	12	120	2	45-51	Congestion; small pyloric ulcer and bleeding points.	Sacrificed 2nd day.
18	12	120	1	44-55	Congestion; antral erosions and duodenal ulcer.	Died 24 hours.
19	5	50	1	39-51	Pyloric and antral bleeding points.	Sacrificed 24 hours.

of the duodenum and/or stomach were seen, after a few injections. Of eight control dogs receiving daily injections of histamine-in-beeswax alone, only one had developed an ulcer when sacrificed in five days.

DISCUSSION

That hemoconcentration does aid and abet the ulcer diathesis experimentally is adequately shown by the data above. There is room for discussion as to the exact mechanism by which it does this. It has been shown (Trevan³²) that with increase in hematocrit readings above the level of 60 to 70, the viscosity of

blood increases in almost a straight line. This, coupled with Poiseuille's demonstration that the rate of flow along narrow passages is inversely proportional to viscosity of fluid, would suggest stasis. As a matter of fact, it has been shown that in human beings with polycythemia vera the blood flow

TABLE III.—Dogs Receiving Subcutaneous Injection of 25 Per Cent Sodium Chloride Solution Alone.

Dog No.	Wt. in Kg.	Amt. NaCl in cc.	No. of histamine injections	Hematocrit change (Initial-Final)	Findings in G. I. tract	Remarks
20	9	90	0	43-51	Congestion; gastric bleeding points.	Sacrificed 6th day.
21	12	120	0	40-48	Congestion.	Died 24 hours.
23	9	90	0	49-54	Moderate congestion.	Sacrificed 24 hours.
24	14	140	0	48-59	Marked duodenal congestion.	Died 6 hours.
25	11	110	0	44-45	Negative stomach and duodenum.	Sacrificed 3rd day.
26	10	100	0	41-53	Marked congestion.	Died 48 hours.

is greatly reduced. (Blumgart *et al.*⁷) Stasis of blood will lead to poor nutrition of tissues. The gastric mucosa, in consequence of such stasis, will readily succumb to the erosive action of acid peptic digestive juices.¹

TABLE IV.—Hematologic Reports and Venesection Dates.

Date	Hemoglobin	Erythrocytes	Leukocytes	Neutrophils	Lymphocytes	Eosinophils	Hematocrit (%)	Reticulocytes (%)
4-26-44	17.5	5,560,000	12,500	..	..	..	52	..
4-29-44	..	..	..	Venesection	..	..	..	..
5-2-44	..	..	..	Venesection	..	..	..	..
5-16-44	15.7	4,860,000	12,800	..	..	..	46	..
6-5-44	16.6	5,670,000	13,700	..	..	..	..	2.4
6-7-44	..	..	..	Venesection	..	..	..	..
6-8-44	14.8	5,910,000	..	..	..	..	43	..
8-2-44	..	..	..	Venesection	..	..	..	..
8-2-44	13.2	4,300,000	..	..	..	..	..	..
11-14-44	12.5	4,350,000	13,250	63	36	1	..	..
7-2-46	17.5	6,400,000	13,800	65	33	1	51	..
7-3-46	..	..	..	Venesection	..	..	..	..
7-5-46	14.8	5,450,000	15,350	61	38	0	48.5	..
7-10-46	..	..	..	Venesection	..	..	..	..
7-26-46	14.8	4,690,000	..	63	35	2	49	..
7-26-46	..	..	..	Venesection	..	..	..	..
8-9-46	13.9	4,790,000	12,150	..	..	..	43	..
9-8-46	13.8	4,550,000	10,350	60	30	2	1	..
11-22-46	14.8	4,800,000	..	..	..	..	44.5	..
12-13-46	..	..	..	Venesection	..	..	..	..
1-10-47	13.2	..	..	..	..	..	41	..

Hemoconcentration may also increase the susceptibility of gastroduodenal mucosa to ulceration through the agency of thromboses of the end vessels. Patients with this disease have a known tendency to increased coagulation and thromboses. It has been shown in this laboratory that thrombosis, spasm and stasis will abet the ulcer diathesis greatly.^{12, 14} Clinically, ulcer has been

reported four times more commonly in polycythemic patients than in normals. (Tinney, *et al.*,³¹ Wilbur and Ochsner³⁵).

Literature on Treatments Suggested for Polycythemia. To break the vicious cycle present in hemoconcentration in the human (polycythemia vera), obviously one would have to cure the disease itself. Various forms of therapy have been suggested. Sauer²⁶ in 1924 tried splenectomy with fatal outcome. The patient's hemoglobin rose immediately following operation and a thrombosis of the portal vein resulted. Singer²⁸ (1930) put forth the gastric origin of polycythemia. Tuchfield³³ (1930) suggested that, as in pernicious anemia, an underfunction of gastric mucosa producing intrinsic factor existed; in polycythemia vera an overfunction is present. Oerting and Briggs²⁴ (1935) lavaged the stomachs of patients with erythremia and obtained good results. They also suggested that polycythemia might be a form of increased secretion of intrinsic factor of the stomach. Kraemer and Asher²¹ (1936) speculated on the possibility of curing both the ulcer associated with polycythemia, and the polycythemia itself by gastric resection, but never followed it through. Guillaume¹⁸ (1937) recommended that gastrectomy be tried. He mentioned that Hitzenberger,²⁰ and Carnot and Caroli,⁹ had performed the procedure with good results. Ehrstrom¹² (1941) reported three resections of the antrum of the stomach for polycythemia. He obtained one good result. The use of phenylhydrazine as introduced by Eppinger¹³ has been the main form of therapy. This drug has destructive action on the precursors of red cells and the bone marrow itself. However, its use is not without its opponents (Giffin and Conner¹⁷). Barron,³ in a recent personal communication, reported a case of polycythemia in which severe reactions (hemoglobinuria, shock) were obtained following the use of phenylhydrazine. Therapeutic venesections had finally to be resorted to. Since the last venesection, this patient has gone two and one-half years without any form of therapy and the hemoglobin has remained within the normal range. Exacerbations may occur even under treatment. More recently spray irradiation of the bones and the radio-active isotopes (P_{32}) are being used in the therapy of this disease.

It is most important to realize that polycythemia vera can in itself be fatal. If the disease goes untreated, a form of myelogenous leukemia may result (Tinney *et al.*,³⁰ 1945). The secondary complications are usually the main causes of mortality associated with this disease. These are the result of thrombosis of the vessels leading to organs such as liver, spleen, brain, stomach (ulcer), etc. (Tinney²⁹ 1942). Therefore, any form of therapy that fails to induce a protracted remission leaves much to be desired. Thrombosis may take place during exacerbations.

The work of Castle,¹⁰ Minot, Murphy²³ has shown the presence of an intrinsic factor necessary for the propagation of red cells. Recent additional work on the newly isolated vitamin B_{12} ,²⁵ by Castle and his co-workers,^{4, 5} and Hall and Campbell, suggest that this vitamin may in some way be related to one of the factors (intrinsic or extrinsic) necessary for hemopoiesis. Whether

the intrinsic factor combines with the extrinsic factor (vitamin B₁₂?) to form a third substance, the antipernicious anemia principle, or whether the intrinsic factor simply permits absorption of the extrinsic factor to take place in patients having pernicious anemia remains to be determined. In pernicious anemia the intrinsic factor is absent, and therefore the disease results. Moreover, patients who have undergone total gastrectomy for carcinoma of the stomach, may, with the lapse of time, develop a primary anemia. Is it not possible that there may be an excess of the intrinsic factor in polycythemia? As a matter of fact, studies along this line have been carried out as far back as the original discovery of the intrinsic factor (present in the stomach), and it has been suggested that gastric resection be used as a form of therapy. In this clinic, several patients with duodenal ulcer have been observed whose records carry an added annotation on the diagnosis sheet suggesting that the patient may have polycythemia. These diagnoses were made on the basis of a relatively high hematocrit and an elevated hemoglobin. None of the patients carried the clinical stigma of the disease observed in patients with primary polycythemia in whom the clinician may be led to suspect the diagnosis from the brick-red or cyanotic appearance of the skin. Yet these patients with duodenal ulcer in whom the diagnosis of coincidental polycythemia had been made appeared to lose readily the hematologic evidences of polycythemia after the performance of a three-quarter gastric resection. Early, therefore, in the ulcer program which has now been under study in this clinic for more than ten years, we began to toy with the idea of performing something akin to a total gastrectomy for primary polycythemia. No sympathetic support for such an undertaking was found amongst our medical colleagues; moreover many patients with primary polycythemia are not good risks for formidable surgery. We had to content ourselves therefore to wait until a patient with all the clinical evidences of polycythemia presented himself, who at the same time exhibited conventional orthodox indications for surgical therapy.

The following case record details such a story. Inasmuch as a long period of time may elapse before another patient is available to us for this type of therapy, we feel some justification for recording our observations on this patient as a preliminary report. In other words, we are suggesting that total gastrectomy may have therapeutic value in primary polycythemia. Patients having this malady run risks so abnormal and unusual that the trial of any treatment which seems to afford promise of alleviation appears to be justified.

CASE HISTORY

J. B. (U. H. No. 743,178), a 52-year-old white male, was first seen in the Medical Outpatient Division on April 17, 1944. At that time his complaints were bloody stools, weakness and nervousness, and pain in the epigastrium, each of five years' duration.

Five years previously the patient first noticed that he passed some blood at stool. At times, he said, he passed only blood and no fecal material. At that time he also began to notice a lot of weakness and occasional dizziness. In 3 months time, his weight fell from 205 to 145 pounds. His local family physician reported to him that roentgen ray

films taken at that time were negative and suggested no further treatment. After a period of time the epigastric pain and other symptoms disappeared, only to recur again periodically. The pain was occasionally relieved by meals. He vomited on occasions and the vomitus contained bright red blood. He complained of dizziness at those times. A gastrointestinal series by his local physician in July, 1943, revealed "ulcers of the stomach." Proctoscopy was performed and some "pinpoint bleeding ulcers" were found in the rectum. He was then apparently placed on a Sippy regimen.

On January 1, 1944, a recurrence of symptoms and bleeding put him in bed, and after that time he had recurrent episodes weekly. On occasions, tarry stools were noticed. *Systemic review* revealed the following pertinent findings:

1. Dull, steady, retrosternal pain, associated with epigastric pain and not related to exertion; relieved by food.
2. Appetite poor, and following eating becoming "full" rather quickly.

Physical Examination.

A well-nourished and well-developed male. Eyes and throat slightly injected; chest clear; blood pressure 120/92. The pulse was regular. There were no masses palpable in the abdomen. Rectal examination revealed nothing. One of his extremities had been amputated below the knee, because of a train accident in 1916.

Laboratory Examination.

Hematologic reports.

April 17, 1944.

Hemoglobin — 16.3 Gm. per 100 cc.

Leukocytes — 14,900

Neutrophils — 61 per cent.

Lymphocytes — 38 per cent

Eosinophils — 1 per cent

April 26, 1944.

Hemoglobin — 17.5 Gm. per 100 cc.

R. B. C. — 5,560,000

Leukocytes — 12,500

Sed. rate (April 17, 1944) (April 25, 1944)

20 min. — .5 mm. .5 mm.

40 min. — 1.0 mm. .5 mm.

60 min. — 1.0 mm. .5 mm.

80 min. — 2.5 mm. .5 mm.

Hematocrit (April 26, 1944) — 52 per cent packed cells

Gastric analysis (without histamine) (April 18, 1944)

31° free acid ($\frac{1}{2}$ hour)

60° total acid

Gross: Peripheral Blood smear.

Micro: Mean corpuscular diameter 7 micra. Differential, PMNs 52 per cent, basophiles 1 per cent, lymphocytes 44 per cent, monocytes 3 per cent. A moderate leukocytosis is apparent with relative lymphocytosis. Most of the lymphocytes are the meso type with some reaction noted in the nuclei. The cellular elements appear quite normal throughout.

Gross: Sternal marrow aspiration. Hematocrit, fat 3 per cent, plasma 38 per cent, ME layer 9 per cent, Erythroid layer 50 per cent. Six-tenths of a cc. was obtained in the first specimen with slight pigmentation of the plasma and the marrow units are quite numerous and appear rather small.

Micro: The ME ratio appears to be shifted somewhat to the myeloid line. The relationship of the myeloid components appears to be normal. The erythropoiesis is normoblastic and has shifted right with some normoblasts found. The megakaryocytes appear to be moderately increased.

Concl.: Generalized hyperplasia of the marrow.

Proctoscopic Examination.

Negative up to 25 cm., except for small mixed hemorrhoids.

Roentgenologic Findings.

April 19, 1944. Colon. Barium enema. Marked redundancy of the large bowel; otherwise negative.

April 20, 1944. *Gastro-intestinal Study.* Giant rugae are present throughout the stomach most marked in the upper half. In addition, there is a distinct filling defect high on the lesser curvature with a soft tissue mass apparent in the prone film in relation to this filling defect. There is rather rapid emptying of the stomach. The distal portion of the stomach shows good peristaltic waves. The duodenum fills well and appears normal and there was no retention at 5 hours. Gastroscopy is advised to aid in differentiating between possible leukemia and carcinoma on the lesser curvature. Blood studies might be of help in determining possible leukemic etiology.

Conclusions. Very bizarre infiltration with giant rugae and filling defect on the lesser curvature due either to leukemia or to carcinoma associated with severe gastritis.

Gastroscopic Examination.

Easily done. Pylorus seen although stomach contracts violently and especially the antrum. Gastric folds are very thick and irregular with deep crevices but not excessively wide. The mucosa is hypertrophied, as in ordinary hypertrophic gastritis, but is also very thick. It could be called hyperplastic. Color is dark red, venous. Excessive secretion and numerous adherent mucous plaques are seen. Near the top of the stomach there appears to be hemorrhage in a few of the crevices. Superficial erosions are noted in various parts, but no distinct ulceration. No other lesion is seen. The impression is that the stomach is small. The appearance is that of hyperplastic hypertrophic engorged mucosa with excessive secretion and superficial erosion. This is compatible with a diagnosis of polycythemia vera and it corresponds with the appearance of the mucosal pattern seen on the film. Spleen is not palpable, but may be visible on film. Note also skin color, color of mucous membrane, injected conjunctiva. Possibility of either true or compensatory polycythemia to be considered.

Course.

Venesection of between 500 to 1000 cc. each time was performed on this man at least 8 times during the next 2 years. On May 15, 1944, he was seen by Dr. C. J. Watson, who suggested that a repeat bone marrow be done in order to clarify the diagnosis. A bone marrow study on June 7, 1944, showed it to be consistent with erythremia.

During this period of time he still complained of blood in his stools occasionally and epigastric distress. Many blood studies were carried on during this time interval. A record of these is shown with venesection dates included.

Blood Volume Studies (April 30, 1946) — 0.6 liters total blood volume.

Cell Indices — (September 9, 1946)

CI = 0.92

MCV = 102.5 μ^3

MCH = 31.1

MCC = 30.3

During this period of time (up until March 11, 1947) the patient continued his varying course. At one time (September 8, 1946 to October 12, 1946) he was admitted to the hospital for medical management of his epigastric distress. While he was on a Sippy regimen he seemed to feel much better. A subsequent gastroscopic examination suggested the presence of an ulcer in the prepyloric area. With this finding, the patient's epigastric distress and his inability to stay on the Sippy diet, it was suggested by one of us (O. H. W.) that he have either a total or something akin to a total gastrectomy. This

might possibly relieve his polycythemia vera and would certainly take care of a possible malignancy in the prepyloric region.

After being admitted to the Surgical Service on April 30, 1947, a total gastrectomy and cholecystectomy were performed by Dr. D. State on May 3, 1947. A combined abdominothoracic incision was used. The upper jejunum was anastomosed to the esophagus; no entero-anastomosis was performed. His postoperative convalescence was marred only by an acute psychotic episode which cleared quickly. He was discharged on May 16, 1947.

Pathology Report.

Gross: Stomach and gallbladder.

The gastric specimen consists of the entire stomach, which is received in two parts fixed in formalin. It measures 34 cm. on the greater curvature, 8 cm. on the lesser curvature, 3 cm. across the esophageal line of resection which is 5 mm. above the cardia, and 3 cm. across the distal line of resection which is 12 mm. below the duodenum. It weighs 372 Gm. The omentum weighs 583 Gm. The stomach shows marked prominence of rugation which is apparent even in the fixed specimen. In the prepyloric region, centered on the lesser curvature, is an irregular area in which the mucosa is flattened and presents a warty appearance. It is somewhat irregularly stellate and measures 5 by 3 cm. in size, approximately. Several lymph nodes are present measuring up to 8 mm. in diameter on the lesser curvature. The gallbladder measures 8.6 cm. in length and 4 cm. in diameter. The mucous membrane is intact, and the wall is thin. There are two conglomerate, black, irregular, soft pigment stones measuring 1 and 2 cm. in diameter respectively.

Micro: Section of the proximal line of resection shows mucous membrane of the esophagus. The adjacent body mucous membrane shows a moderately severe mononuclear leukocytic infiltration with several follicles in the mucosa and submucosa. Five sections from the area of scarring in the pre-pyloric region show a similar appearance. There are scattered healed and active erosions, beneath which there is an extensive infiltration by small lymphocytes extending into the submucosa with numerous follicles containing germinal centers. The intensity of the infiltrate raises the question of a possible lymphoblastoma. The members of the pathology staff who have seen this slide feel that the normal lymphoid architecture present indicates the infiltrate is inflammatory in origin. Sections of the body show only scattered foci of mononuclear infiltration. The regional lymph nodes show simple hyperplasia. The gallbladder shows a thin wall with intact mucous membrane. Throughout the wall there are scattered mononuclear leukocytes.

Conclusion:

1. Erosive gastritis.
2. Chronic cholecystitis with cholelithiasis.
3. Simple hyperplasia of regional lymph nodes.

His course since operation has been relatively good. Though he has lost weight (20 pounds) he is able to eat everything. Occasionally, he has some dysphagia and pain in his incision.

Since operation the hemoglobin has remained between 13 and 15 Gm. and the leukocyte count has been markedly lowered. His blood volume has been reduced from 9.6 liters to 4.8 liters. There has been no necessity for phlebotomy.

Recent studies follow:

April 22, 1948 — Blood volume, 4.9 liters.

January 26, 1949 — Blood volume, 4.8 liters. The extra-cellular space — 15.4 liters.

January 26, 1949 — Hemoglobin, 13 Gm., erythrocytes 6,000, neutrophils 52 per cent, lymphocytes 40 per cent, monocytes 3 per cent, eosinophils 3 per cent, and basophils 2 per cent, hematocrit 40 per cent.

Bleeding time, 1 min., 45 seconds.

Clotting time, 4 minutes.

Cell indices:

MCV — 96.4

MCH — 31.3

MCC — 32.5

Plasma protein, 6.6

Reticulocyte count — 1.2

Fractional globulin, the total proteins 7.2

Albumin 3.9

Globulin 3.3

Pseudo-globulin 2.2

Euglobulin 1.1

Beta-globulin 0.85

Gamma-globulin 1.35

Bone Marrow Biopsy.

(sternal)

Fat	0.5%
Perivascular cells	1.5
Plasma	47.0
Myeloid-erythroid	3.0
Erythrocytes	48.0
Total aspirated fluid	1.5 cc.

There is no evidence of hyperplasia.

Normoblasts (16.2 per cent) are relatively, slightly decreased.

Neutrophils and their precursors (60.1 per cent) show no important changes. Eosinophils (4.1 per cent) are slightly increased. Basophils (0.6 per cent) show no important changes.

Megakaryocytes appear slightly increased, and marrow platelets are numerous.

Lymphoid cells (19 per cent) are relatively increased. There is a slight increase in pigment-containing macrophages, and in plasma cells.

Peripheral Blood. Erythrocytes show no outstanding changes. Platelets appear increased in number. The total leukocyte count is normal. Differential: N-63.5; L-23.5; M-10.5; E-1.5; B-1. Leukocytes show no remarkable changes. No normoblasts could be found.

Previous reports on this patient have indicated that the findings might be compatible with a diagnosis of polycythemia vera. However, normoblasts have not been found in the blood in this case insofar as I can determine from our records, and from the standpoint of the changes in the blood and in the bone marrow, a conclusive diagnosis has not been possible.

Conclusion. The one finding which might favor a diagnosis of polycythemia vera is the megakaryocytosis and what appears to be a peripheral thrombocytosis. This finding is not completely specific.

Roentgenologic Findings.

January 26, 1949. Gastro-intestinal Series. Total gastric resection is noted. There is prompt filling of both the afferent and efferent loops. Both the afferent and efferent loops in the region of the anastomosis are somewhat dilated. No other abnormalities noted.

CASE SUMMARY

This is a case of a 52-year-old white male admitted to the hospital because of recurrent episodes of hematemesis and melena and epigastric distress. Over a period of three years, hematologic studies had revealed the presence of a polycythemia vera, which was confirmed by bone marrow studies. Roentgenologic examination showed the presence of giant rugae within the stomach, with a filling defect on the lesser curvature due either to leukemia or to carcinoma with gastritis. Gastroscopic studies suggested the possibility of a polycythemia vera. Venesection on at least eight different occasions failed to relieve this man's symptoms, but a course on a Sippy regimen did. Because of the patient's inability to stay on this regimen coupled with the presence of polycythemia vera and a possible malignant lesion of the stomach, total gastrectomy was performed. Since operation, his hemoglobin has remained between 13 and 15 Gm. His blood volume has been reduced by one-half. There has been no necessity for phlebotomy.

SUMMARY AND CONCLUSION

1. Hemoconcentration attained by means of plasmaphoresis red cell replacement, and by means of hypertonic salt dehydration aids and abets the histamine-in-beeswax provoked ulcer in dogs.

2. A case is presented in which gastrectomy as a form of permanent therapy for polycythemia vera has been tried with good results thus far, two years after operation.

The authors wish to express their appreciation to Dr. William Townsend and Dr. John R. McQuillan for their kind help in the performance of the animal experiments.

BIBLIOGRAPHY

- ¹ Baronofsky, I. D., and O. H. Wangenstein: Erosion or Ulcer (Gastric and/or Duodenal) Experimentally Produced Through the Agency of Chronic Arterial Spasm Invoked by the Intramuscular Implantation of Epinephrine or Pitressin in Beeswax. *Bull. Am. Coll. Surg.*, **30**: 59, 1945.
- ² Baronofsky, I. D., K. A. Merendino, T. E. Bratrud and O. H. Wangenstein: Fate of Intravenous Injected Fat: Its Role in the Production of Ulcer. *Proc. Soc. Exper. Biol. & Med.*, **59**: 231, 1945.
- ³ Barron, Moses: Personal Communication, 1949.
- ⁴ Berk, L., D. Denny-Brown, M. Finland and W. B. Castle: Effectiveness of Vitamin B₁₂ in Combined System Disease, Rapid Repression of Neurologic Manifestations and Absence of Allergic Reactions in a Patient Sensitive to Injectable Liver Extracts. *New England J. M.*, **239**: 328, 1948.
- ⁵ Berk, Lionel, W. B. Castle, A. D. Welch, R. W. Heinle, Rudolph Anker and M. Epstein: Observations on the Etiologic Relationship of Achylia Gastrica to Pernicious Anemia. X. Activity of Vitamin B₁₂ as Food (Extrinsic) Factor. *New England J. M.*, **239**: 911, 1948.
- ⁶ Bing, H. J.: *Ugesk. f. Laeger*, **82**: 337, 1920. (*British M. J.*, 1920, i Epitome No. 625.)
- ⁷ Blumgart, H. L., S. L. Gargill and D. R. Gilligan: Studies on the Velocity of Blood Flow. XV. The Velocity of Blood Flow and Other Aspects of the Circulation in

- Patients with "Primary" and Secondary Anemia and in Two Patients with Polycythemia Vera. *J. Clin. Investigation*, **9**: 679, 1930-31.
- ⁸ Boyd, Wm.: The Relationship of Polycythemia to Duodenal Ulcer. *Am. J. M. Sc.*, **187**: 589, 1934.
 - ⁹ Carnot and Caroli: Quoted by Guillaume.
 - ¹⁰ Castle, W. B.: Observations on the Etiologic Relationship of Achylia Gastrica to Pernicious Anemia. I. The effect of administration to patients with pernicious anemia of the contents of the normal human stomach recovered after the ingestion of beef muscle. *Am. J. M. Sc.*, **178**: 748, 1929.
 - ¹¹ Castle, W. B., C. W. Heath and M. B. Strauss: Observations on the Etiologic Relationship of Achylia Gastrica to Pernicious Anemia. *Am. J. M. Sc.*, **182**: 741, 1931.
 - ¹² Ehrstrom, R.: Operative Behandlung der Polycythaemie. *Acta. Med. Scand. Supp.*, **123**, **179**: 176, 1941.
 - ¹³ Eppinger, H., and K. Kloss: Zur Therapie der Polyzythamie. *Therap. Monatsch.*, **32**: 322, 1918.
 - ¹⁴ Friesen, S. R., and O. H. Wangenstein: Experimental Burns Accompanied by Histamine Administration Abets the Ulcer Diathesis. *Proc. Soc. Exper. Biol. & Med.*, **63**: 245, 1946.
 - ¹⁵ ———: Role of Hemoconcentration in Production of Gastric and Duodenal Ulcer Following Experimental Burns. *Proc. Soc. Exper. Biol. & Med.*, **64**: 81, 1947.
 - ¹⁶ Friesen, S. R., K. A. Merendino, I. D. Baronofsky, F. B. Mears and O. H. Wangenstein: The Relationship of Bone Trauma to the Development of Acute Gastroduodenal Lesions in Experimental Animals and in Man. *Surgery*, **24**: 134, 1948.
 - ¹⁷ Giffin, H., and H. Conner: The Untoward Effects of Treatment by Phenylhydrazine Hydrochloride. *J. A. M. A.*, **92**: 1505, 1929.
 - ¹⁸ Guillaume, M. A. C.: Etude Physiopathologique Sur le Role Hematopoietique de l'Estomac L'Hypogastrie et L'Hypogastrie et leurs Rapports avec L'Hematopoiese. *Arch. d. Mal de l'app. digestif.*, **27**: 375, 1937.
 - ^{18a} Hall, B. E., and D. C. Campbell: Vitamin B₁₂ Therapy on Pernicious Anemia. I. Effect on Hematopoietic System: Preliminary Report. *Proc. Staff Mayo Clinic*, **23**: 584, 1948.
 - ¹⁹ Harkins, H. N.: The Treatment of Burns. Charles C Thomas, Springfield, 1942.
 - ²⁰ Hitzenger: Quoted by Guillaume.
 - ²¹ Kraemer, M., and M. Asher: The Association of Erythemia and Duodenal Ulcer. *Am. J. M. Sc.*, **191**: 234, 1936.
 - ²² Merendino, K. A., S. S. Litow, W. D. Armstrong and O. H. Wangenstein: The Experimental Production of Erosions or Ulcer (Gastric and/or Duodenal) in Animals by Fracture or Curettement of Bone Marrow. *Bull. Am. Coll. Surg.*, February 1945.
 - ²³ Minot, G. R., and W. P. Murphy: A Diet Rich in Liver in the Treatment of Pernicious Anemia: Study of One Hundred and Five Cases. *J. A. M. A.*, **89**: 759, 1927.
 - ²⁴ Oerting, H., and J. F. Briggs: The Influence of Gastric Lavage on Familial and Nonfamilial Erythemia. *J. A. M. A.*, **104**: 250, 1935.
 - ²⁵ Rickes, E. L., N. G. Brink, F. R. Koniuszy, T. R. Wood and Karl Folkers: Crystalline Vitamin B₁₂. *Science*, **107**: 396, 1948.
 - ²⁶ Sauer, H.: Splenectomy in Polycythemia. *Arch. Int. Med.*, **50**: 1641, 1924.
 - ²⁷ Schneider, N.: Ein Beitrag Zur Frage der Polyglobulie. *Wien. Klin. Wchnschr.*, **20**: 413, 1907.
 - ²⁸ Singer, K.: Die experimentellen Grundlagen des Problems der Magentherapie hamatologischer Zustandsbilder. *Wien. Klin. Wchnschr.*, **43**: 1597, 1930.
 - ²⁹ Tinney, W. S., Jr.: The Complications of Polycythemia Vera. Master's Thesis, Graduate School of the University of Minnesota, 1942.
 - ³⁰ Tinney, W. S., B. E. Hall and H. Z. Giffin: The Prognosis of Polycythemia Vera. *Ann. Int. Med.*, **20**: 306, 1945.

- 31 ———: Polycythemia Vera and Peptic Ulcer. Proc. Staff Meetings Mayo Clinic, **18**: 24, 1943.
- 32 Trevan, J. W.: The Viscosity of Blood. Biochem. J., **12**: 60, 1918.
- 33 Tuchfield, F.: Ulcus duodeni und Polyglobulie zur Frage: Magenfunktion und rotes Blutbild. Med. Klin., **27**: 130, 1931.
- 34 Weber, F. P., and J. H. Watson: Chronic Polycythemia with Enlarged Spleen. Probably a Disease of Bone Marrow. Internat. Clinics, **4**: 47, 1905.
- 35 Wilbur, D. L., H. C. Ochsner: The Association of Polycythemia Vera and Peptic Ulcer. Ann. Int. Med., **8**: 1667, 1935.
- 36 Wood, G. O., and A. Blalock: Effects of Uncomplicated Hemoconcentration (Erythrocytosis) with Particular Reference to Shock. Arch. Surg., **42**: 1019, 1941.

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

SECOND REPORT*

GEZA DE TAKATS, M.D., LEROY E. WALTER, M.D.,
AND JACK LASNER, M.D.

CHICAGO, ILLINOIS

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE,
THE UNIVERSITY OF ILLINOIS HOSPITAL AND ST. LUKE'S HOSPITAL, CHICAGO

IN A PREVIOUS COMMUNICATION¹ two of us reported the use of unilateral splanchnicectomy for intractable pain of pancreatic origin. Since this report we have accumulated further experience which has helped to crystallize our indications for operation and the results to be expected from it. The literature has been quoted and discussed in our previous report and only additional data will be considered in this report.

THE CLINICAL MATERIAL

Seven splanchnicectomies, partly unilateral, partly bilateral, have been done to date for intractable pancreatic pain. A brief summary of their clinical history is as follows:

Case 1.—(Previously published.) C. H., hospital No. 108768. A 49-year-old white male was admitted to the Research and Educational Hospital on December 10, 1946, with complaints of pain in the epigastrium radiating posteriorly to the back which had been present for 3 months prior to admission. There had been vomiting shortly after meals for the 10 days prior to admission, shortness of breath, and constipation of 3 months' duration. The pain was described as constant and dull aching, starting in the mid-epigastrium just to the right of the midline and radiating posteriorly to the back in the midline around the level of the lower dorsal vertebrae. There was a weight loss of 15 pounds in 3 months and a marked anorexia. There was no history of clay colored stools or dark urine.

Physical examination revealed a patient of emaciated appearance, chronically ill. Temperature was 97.0° F., pulse 70, respirations 25, and weight was 138 pounds. The heart was normal. There were a few expiratory wheezing râles in the right upper lobe. The abdomen was flat but there was a sense of fullness in the epigastrium, although no definite mass was palpated. The upper abdomen in the mid-epigastrium was moderately tender as were the left hypochondrial and left lumbar areas. Rectal examination was negative. The red cell count was 3,730,000, white blood count 9,800. Serum amylase was 146 on December 21, 1946, 612 on December 30, 1946, and 61 on January 11, 1947. Total proteins were 7.5 per cent, with a serum albumin of 5.5 per cent and a serum globulin of 2.0 per cent. Fasting glucose was 143 mg., nonprotein nitrogen 38, and chlorides 511 mg. per 100 cc. An upper gastro-intestinal roentgenogram and barium enema were reported as normal. Roentgenogram of the chest revealed a circular density to the left upper lobe considered to be a metastatic lesion. Roentgenogram of the dorsal spine was negative. After adequate preparation for surgery, which consisted in part of multiple blood transfusions, the patient was operated upon on January 2, 1947, by Dr. Warren H. Cole. When the peritoneum was opened a

* Submitted for publication April, 1949.

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

large tumor mass, occupying the posterior portion of the pancreas and extending upward to the liver edge, was seen. The tumor was estimated to measure 3 by 5 inches. There were no metastases to the liver, although the superior extension of the tumor consisted chiefly of metastatic nodes. In spite of the probable metastasis to the lung, resection appeared indicated, in view of the patient's extreme pain. However, closer inspection of the tumor revealed a superior portion of the mass with its metastatic nodes completely surrounding the celiac axis. The hepatic artery could be felt coming out of the center of the mass. This one point, in addition to the complete incurability, caused the decision against resection to be made, so the abdomen was closed.

In the postoperative period, this patient's pain continued and required large doses of narcotics and sedation for effective relief. However, even heavy doses of narcotics failed to give him adequate relief. For these reasons consideration was given to the possibility of splanchnic nerve block, and perhaps resection of the nerve if indicated by a favorable response to the block. On January 10, 1947, a right paravertebral sympathetic block was done from sixth to the tenth dorsal segment, injecting 10 cc. of 1 per cent procaine at each level. Twenty minutes after the block, the patient stated that the epigastric pain had completely disappeared. For 12 hours after the block there was no return of pain. The patient had not received sedation or narcotics for 8 hours preceding the block.

On January 14, 1947, under intratracheal anesthesia, one of us (G. de T.) performed a resection of the right splanchnic nerve from the level of the diaphragm to the seventh dorsal segment. The sympathetic chain was also excised from above the ninth dorsal to below the twelfth dorsal segment. A small tear was made in the pleura during this dissection, which was closed with interrupted cotton sutures.

Convalescence from this operation was uneventful and there was prompt relief from the epigastric pain. He was discharged from the hospital on January 23, 1947, 9 days after the splanchnicectomy. At the time of discharge he was eating well and had gained several pounds in weight. The relief of pain, however, lasted for only a period of 3 weeks. Deep roentgen-ray therapy to the pancreas was begun on January 31, 1947, and shortly after this the epigastric pain returned. The pain became progressively more severe, and again it was necessary to administer narcotics for efficient relief. The patient refused rehospitalization and became progressively worse. Death occurred on March 4, 1947. Permission for an autopsy was not obtained.

Case 2.—(Previously published.) J. A. W., Hospital No. 109477. A 22-year-old white, unmarried female was admitted to the Research and Educational Hospital on December 15, 1946, with complaints of extreme, constant aching pain in the epigastrium radiating to the left flank. She had been well until December, 1945, when she first had noted a dull intermittent pain in the left lumbar area radiating in a radicular fashion to the left hypochondrium. These attacks of pain would occur several times daily and occasionally be associated with vomiting and extreme weakness. She had been hospitalized at another hospital in January, 1946, and we were informed that a left heminephrectomy of the lower pole had been performed at this time, because of a diagnosis of carbuncle of the kidney. The patient remained in the hospital for a period of 5 weeks. The pain persisted after surgery, and 2 weeks following her discharge from the hospital she was readmitted, remaining in the hospital until August, 1946. During this period of hospitalization she had had daily chills with temperature elevations to 104°F. During the second hospital stay, she noted a swelling in the epigastrium; there were intermittent episodes of vomiting, a progressive weakness and weight loss, and a relatively persistent pain in the epigastrium and left lumbar region. After a month of hospitalization, the patient was again discharged. Symptoms persisted, and in March the patient went on an alcoholic bout because of pain. Severe diarrhea developed after 1 week of drinking and this caused the patient to terminate her alcoholism. She was hospitalized

for the third time and a gastro-intestinal roentgen ray series at this time revealed a large mass present posterior to the stomach and displacing this organ anteriorly. This was interpreted as a large pancreatic cyst. The patient was reoperated upon through the old nephrectomy incision, but there were no reported abnormal findings. One week after the operation a roentgenographic study of the gastro-intestinal tract revealed a dramatic reduction in size of the cystic mass. After healing of the lumbar incision, the patient was discharged from the hospital, and stated that she felt somewhat improved, although periodic attacks of pain in the epigastrium and left flank continued to occur. For the 24 hours prior to admission to the Research and Educational Hospital the pain had become severe, and there had been a voluntary dietary restriction, but no vomiting.

On her first admission to this hospital the patient was acutely ill. The temperature was 102°F., respirations 24, and blood pressure 110/60 mm. of mercury. There was a marked dehydration, emaciation, and weakness. The heart and lungs were normal. Diaphragmatic excursions were normal. There was a marked distention of the upper abdomen, especially in the epigastrium, and this portion of the abdomen was rigid. There was also some rigidity of the lower abdomen, but only to a slight degree. The entire upper abdomen was acutely tender. The bowel sounds were active, but not increased. The liver and spleen were not palpable. There was moderate tenderness in the left flank posteriorly. There was no demonstrable fluid wave. Pelvic and rectal examinations were negative. The red blood count was 3,800,000 and the white cells were 28,000. The serum amylase was 42 units. On succeeding days the amylase levels were as follows: December 16, 1946, 23; December 21, 38; December 27, 111; January 4, 1947, 69; January 8, 40; January 11, 43; January 14, 50. The remainder of the blood chemical tests on the day of admission showed: total protein 6.9 per cent with 4.4 per cent serum albumin, and 2.5 per cent serum globulin. Nonprotein nitrogen was 35 mg.; glucose was 68 mg. per 100 cc. of blood.

A flat plate of the abdomen revealed no free air beneath the diaphragm. There were irregular multiple calcareous densities to the left of the first lumbar vertebra, interpreted as pancreatic calculi. An intravenous pyelogram revealed no abnormalities.

A Levine tube was inserted into the stomach and continuous Wangenstein suction was instituted. Intravenous fluids were administered. Penicillin 50,000 units every 3 hours was begun. Under this conservative treatment, there was some slight diminution of the pain during the first 24 hours, but the tenderness and epigastric distention persisted. The white blood count was 28,000 the day of admission and then gradually dropped until the fifth day, when it was 14,300. On the third day there was some lessening of the abdominal distention, and considerably less tenderness. A diagnosis of pancreatic lithiasis and pancreatitis with possible pancreatic cyst was made, and following several blood transfusions and further hydration of the patient, an exploratory laparotomy was performed by Dr. Warren H. Cole on December 31, 1946. When the peritoneal cavity was opened, a large mass was found pushing the stomach anteriorly in the midline. The gallbladder was normal. The mass consisted of the pancreas, enlarged to three or four times its normal size, nodular and very firm. The fact that it displaced the stomach forward had resulted in an erroneous preoperative impression that it was a cyst. The entire pancreas was involved in the process, although the tail was not quite so large. Further exploration of the abdomen was unrevealing, and the wound was closed in layers without drainage. The postoperative course was uneventful. The pain, however, continued and there was severe anorexia with irregular episodes of vomiting, which usually occurred after the intake of even small quantities of food. Parenteral fluid therapy was necessary to maintain the patient's nutritional status at all. Parenteral high vitamin therapy and penicillin were continued, and in addition a course of streptomycin (1 Gm. per day) was given for a 10 day period. Considerable sedation was necessary to control pain at all times. There was some slight improvement

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

on the fourteenth day after surgery and, at the patient's request she was discharged from the hospital with instructions to return to the outpatient department in 1 week for observation. Readmission to the hospital occurred on January 20, 1947. The patient stated that, since leaving the hospital, she had had almost continuous pain, nausea, vomiting and weight loss, so that on admission she weighed only 78 pounds. Her problem remained the same—continuous narcotic administration was necessary to control pain, amounting to 3 grains of pantopon a day.

Consideration of splanchnic nerve block or resection was suggested to attempt to relieve this pain and accordingly, on January 30, 1947, a dorsal sympathetic block was performed. Ten cubic centimeters of 1 per cent procaine were injected paravertebrally on the left side in each of the segments from the sixth to the tenth dorsal. The block was done in the afternoon, and in the morning preceding the block no sedation or narcotics had been administered. Within 10 minutes after the paravertebral block, the patient reported that there was complete relief of pain, and for the first time in many weeks the patient was comfortable. She slept that night without sedation and felt rested. Because of this result, resection of the left splanchnic nerve was deemed advisable. On February 4, 1947, one of us (G. de T.) performed a left splanchnic nerve resection, including removal of the dorsal sympathetic chain between the ninth and twelfth dorsal. This operation was performed under intratracheal anesthesia. The eleventh rib was resected. Reflection of the pleura revealed considerable inflammatory reaction in the posterior mediastinum. The patient tolerated the surgery very well and her postoperative course was uneventful. There was complete relief of the pain in the epigastrium. Abdominal distention disappeared. There was moderate pain over the thoracotomy incision for several days, but no sedation was required after the second day. The patient began to eat a general diet, and on discharge from the hospital on February 12, 1947, she weighed 82½ pounds. She weighed 107 pounds 2½ months after splanchnic section, a gain of 20 pounds. Relief of pain persisted on re-examination 6 months after operation. Follow-up inquiries after this period were unsuccessful. She appeared once more at the clinic with an acute respiratory infection but could not be hospitalized.

Case 3.—Muriel P., hospital No. 111-582, a 43-year-old white female was admitted to the Research and Educational Hospital for the first time on May 15, 1947, complaining of severe persistent pain in the right epigastric region of 18 months' duration. Her surgical history started at the age of 19, at which time an appendectomy and panhysterectomy were done. The hysterectomy was done because "the organs were infected from a previous childbirth." In 1935 she was operated upon for adhesions causing intermittent cramps with nausea and vomiting. The onset of her present illness dated back to February, 1945. At this time she had a sudden series of attacks of hematemesis. Each time, she stated, she vomited about a cupful of bright red blood. Severe, steady, peri-umbilical pain and tarry stools were associated with these attacks. In spite of negative roentgen rays a laparotomy was done at another hospital and her gallbladder was removed. She felt fine until August, 1945, when she was seized with an attack of severe, steady, peri-umbilical pain, nausea and vomiting (greenish-yellow). Gastric suction relieved her and her abdomen was explored again. She was told she had cancer of the liver. She remained at the hospital for about 9 months. During this time she suffered a left hemiplegia, pneumonia and an infection of her left arm. Her weight dropped from 120 to 65 pounds. During the 18 months preceding her admission to the Research and Educational Hospital the pain was of a dull, steady nature with frequent acute severe exacerbations requiring up to 1½ grains of morphine per day. Infrequently the pain radiated to the tip of the right scapula. There was no history of jaundice, clay-colored or fatty stools. She stated that she had always been nervous.

Physical examination revealed a patient who did not appear acutely or chronically ill. Her weight was 126 pounds. TPR were normal. Blood pressure was 118/88 mg. of mercury. Three scars on the abdomen were noted. There was an area of tenderness around the umbilicus. Liver, kidneys and spleen were not palpable. There was an enlarged right inguinal lymph node. Otherwise the examination was negative.

Laboratory examinations revealed a negative urine. The red cell count was 4.5 million with 14 Gm. of hemoglobin. The white cell count was 5,800. The fasting blood sugar was 86 mg. per cent, NPN 28, chlorides 485, serum albumin 5.5, serum globulin 2.5, serum amylase 84. Cephaline flocculation was negative and the thymol turbidity test was 8.0 units. Gastric analysis contained some blood. Total protein was 8.4. Blood Kahn and Wassermann were negative. The colloidal gold was normal.

On May 19, 1947, a flat plate of the abdomen and roentgen ray studies of the dorso-lumbar spine revealed small calcification to the right of the upper lumbar spine which was suspected of lying in the pancreas. Skull films were noncontributory.

On June 12, 1947, the abdomen was reopened, revealing nodules which studded the entire parietal peritoneum. These were most numerous in the pelvis and over the surface of the liver. They were suggestive of a foreign body reaction, perhaps due to talc or sulfa crystals. Biopsy material from the omentum and liver revealed extensive fat necrosis. On these findings the diagnosis of late sequelae following chronic pancreatitis was made.

The postoperative course was uneventful except for the frequent demand for sedatives, narcotics and analgesics. She received 3 dorsal paravertebral procaine injections. Relief of her symptoms would last about 2 days, only to recur and require Demerol and placebos.

On July 15, 1947, the right sympathetic chain was removed from above D10 to below D12. The splanchnic nerve was resected from the mid-thoracic level to the diaphragm. She left the hospital on July 24, 1947, free of symptoms. Follow-up August 1, 1947, revealed slight incisional pain, good appetite and gain of weight. November 6, 1947: No pain, feels excellent and gained 30 pounds. November 11, 1948: Gained another 14 pounds. Complete relief of right sided pain. Had two mild attacks of left subcostal pain. On February 16, 1949, the patient reported by mail that except for an occasional "twitch" in the epigastrium her pain was completely relieved.

Case 4.—Alfred K., hospital No. 114-004, a 48-year-old white male, was admitted to the Research and Education Hospital on September 30, 1947, with a three-year history of intermittent epigastric pain, loss of weight and anorexia. A resume of his history reveals that in January, 1944, he noted epigastric distress and occasional pain for the first time. He was treated with diet of milk and cream and aluminum hydroxide. He continued to work until June, 1944, when he experienced a sudden "terrific pain" in the epigastrium. He obtained relief with a hypodermic injection, but a dull ache persisted for 3 or 4 days. Thereafter, fatigue and loss of weight were progressive. In April, 1947, he noted a recurrence of dull epigastric pain. A diagnosis of peptic ulcer was made by roentgen ray. Dietary regimen was tried again but failed to bring relief. By this time complete anorexia was present. Pain was more severe in character especially during exacerbations. He was hospitalized elsewhere, and was unable to eat or drink. He lost 30 pounds over a 2-week period. At this time he gradually became jaundiced and passed clay-colored stools. On May 9, 1947, an abdominal exploration revealed an old perforated peptic ulcer which had penetrated into the pancreas. A gastric resection and cholecystostomy were performed. In 2 weeks the jaundice had cleared and stools returned to normal. Shortly afterward the right upper quadrant pain returned and was severe enough to require hypodermics. He again sought aid and on September 4, 1947, another laparotomy was done at Presbyterian Hospital. The gastro-enteric stoma was adequately patent. The head of the pancreas was enlarged and hard, and there was no free fluid in the peritoneal cavity. A biopsy specimen was taken from the pancreas which showed only a mild fibrosis. A lymph node removed from this area showed no pathologic features. A right celiac ganglionectomy and splanchnicectomy were done. Postoperatively, the old cholecystostomy tract opened and

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

drained voluminous amounts of bile. Jaundice recurred and stools became acholic. Gradually the icterus cleared and the stools returned to normal color. He was completely relieved of pain for about one week, and the pain recurred in the lower abdomen. Psychiatric consultation confirmed the diagnosis of organic pain. Roentgen rays of his chest and gastro-intestinal tract were negative. Repeated serum amylase determinations were normal.

Admission to the University of Illinois Hospitals revealed a well-developed patient, somewhat emaciated and appearing chronically ill. He weighed about 110 pounds. Temperature 100°F., pulse 104, respirations 18, blood pressure 116/74 mm. of mercury. The sclerae showed no discoloration. A few scattered small lymph nodes were palpable in the cervical region. The heart and lungs were negative. There was a non-draining fistula over the gallbladder area. The abdomen was flat and tense. Liver, kidneys and spleen were not palpably abnormal. Rectal examination was negative. The red cell count was 5.5 million, hemoglobin 12 Gm. per 100 cc., hematocrit 44, white cells 15,400. Prothrombin time was 18 seconds. The urinary specific gravity was 1.026 and the urine contained many red cells with two-plus albumin and bile. Fasting blood sugar was 130, NPN 20, NaCl 446, serum albumin 3.3, globulin 3.2, icteric index 10, amylase 71. Thymol turbidity 7.7 units, cephalin flocculation negative in 48 hours. Stools were of normal size, color and consistency. Serology was negative.

On October 6, 1947, a barium study of the upper intestinal tract showed a normal esophagus and a minimal amount of gastric retention at the end of 5 hours. The gastro-enterostomy appeared adequate.

On October 11, 1947, urobilinogen was absent from the stool. Three days later a right dorsal paravertebral procaine injection was done from D9 to D11 with some relief from pain. On October 16, 1947, his stool was not completely acholic but contained an increased amount of fat. On October 18, the icteric index was 11, serum amylase 95. On October 21, 1947, a right dorsal sympathectomy (D9 to below D12) and splanchnic nerve section (D9 to diaphragm) was done. Pain promptly subsided but he continued to have a total biliary fistula. On the second postoperative day he was given 12 tablets of pancreatin 3 times daily.

On November 7, 1947, the abdomen was opened again by Dr. Warren H. Cole. The head of the pancreas contained a hard nodule 5 cm. in diameter. Carcinoma was suspected; however, because of the intermittency of the acholic stools some doubt was entertained as to the malignant character of the lesion. Since the common duct was completely obstructed a cholecysto-jejunostomy was done, using a Roux Y.

On November 12, 1947, the patient became irrational, depressed and unresponsive. This lasted for about 30 minutes. The next 6 days were uneventful, and on November 18, 1947, he had a similar episode from which he did not recover. Permission for autopsy was not granted.

Case 5.—Vincent J., St. Luke's Hospital No. 103654, a white male, age 36, was admitted for the first time on December 13, 1947, with a 6-year history of right upper quadrant pain. For the year preceding admission he suffered from intermittent pain in back and right shoulder. At the onset the pain was described as being severe, sharp and radiating across his abdomen. This was accompanied by a severe burning sensation in the epigastrium. Each attack would last anywhere from 5 hours to 5 days, during which time he vomited bile-stained, watery material. The right upper quadrant and back pains were almost constant for about 3 months before admission. He required 100 to 200 mg. of Demerol daily. One month before admission he developed a diarrhea which was light colored and watery. At times, he stated, the stools were white. He lost about 15 pounds in 6 months. There was never any jaundice. On pancreatin for 3 weeks prior to admission.

In 1931 he had an appendectomy, in 1943 a cholecystectomy for lithiasis, and in 1946 an exploratory laparotomy and prolonged common duct drainage. At this time the diagnosis of calcareous pancreatitis was made. Total pancreatectomy was advised, but patient refused this operation.

Physical examination revealed an emaciated man who appeared much older than his stated age of 36. The pupils were pin-point in size, but reacted to light and accommodation. The abdomen was rigid but not tender. No masses were palpable. The liver and spleen were not enlarged. The otherwise negative urine contained 75 mg. albumin. The red cell count was 5 million with 14.6 Gm. hemoglobin; white blood count 8,400 with 73 polymorphs and 21 lymphocytes; NPN 24, blood sugar 110, cholesterol 158, chloride 550, CO_2 65.5 volume per 100, amylase 32, calcium 11.3, Kahn negative, TPR normal,

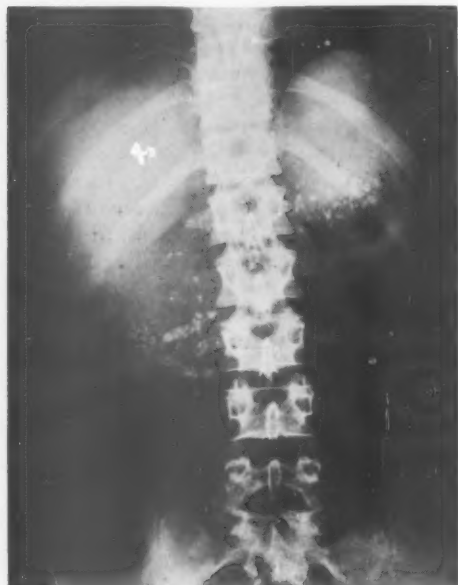


FIG. 1.—Flat plate of the upper abdomen in the case of V. J. (Case 5). Note the massive calcareous deposits, involving the head, body and tail of the pancreas. The head seems to be somewhat enlarged. Patient's pain originally was entirely right-sided, but after relief of this pain by right splanchnicectomy the pain shifted to the left. The X-ray indicates that the entire gland is involved in the calcareous process. The deposits disappeared from the head after prolonged pancreatic drainage.

blood pressure 153/90 mm. of mercury. Flat plate of the abdomen showed massive calcium deposits involving most of the pancreas (Fig. 1). On two occasions when he suffered severe pain, a right dorsal paravertebral procaine injection from D6 to D10 brought relief. During the first 5 days of hospitalization he required daily 400 mg. of Demerol, occasionally morphine gr. $\frac{1}{4}$ and barbiturates.

On December 19, 1947, a right dorsal sympathectomy and splanchnic section were done from D9 to the diaphragm. His postoperative course was uneventful except for a complaint of suprapubic and testicular pain. Urine studies and intravenous pyelogram were negative. Glucose tolerance December 24, 1947, was 101, 235, 243, 101 mg. per 100. During the first week after surgery he only required 1 or 2 narcotic administrations. Thereafter a barbiturate at bedtime was all he asked for. He left the hospital on December 31, 1947, greatly relieved.

His second admission was on March 7, 1948. He stated that one month after leaving the hospital, he noticed a hard, tender mass in the right upper abdomen, which varied in size from day to day. He also complained of sharp, gaslike pains in the left upper abdomen. He gained 15 pounds. There was no jaundice and his

stools were inclined to be soft and light colored. He averaged 2 stools a day and was taking 2 tablets of pancreatin 3 times daily. He again started taking narcotics. Physical examination revealed the presence of a large grapefruit sized mass in the right upper quadrant with no jaundice. Laboratory examinations differed from the previous reports in so far as the intravenous glucose tolerance test which had greatly improved showed 92, 154, 142, 117, 105 mg. per 100. Flat plate of the abdomen revealed a pancreatic retention cyst.

On March 17, 1948, the abdomen was reopened and the cyst was drained and marsupialized by Dr. John T. Reynolds. The cavity of the cyst contained many stones, some adherent to the cyst wall. Enzyme studies of the pancreatic and duodenal secretions were made. Whereas there was no amylase activity in the duodenal fluid, the pancreatic fluid amylase activity rose to 2048 units. Twenty cubic centimeters of pancreatic fluid mixed with 700 mg. of washed out rat intestine produced almost complete digestion of the intestine in 24 hours. A similar test with duodenal secretion had no effect on the rat intestine. The average measured 24 hour output of pancreatic fluid ranged between 800

to 1000 cc. By the fifth postoperative day, codeine gr. $\frac{1}{2}$, aspirin gr. 10 once daily were all the analgesics he required. He was discharged April 1, 1948.

He was readmitted July 5, 1948, for evaluation of pancreatic fistula. Since the previous admission he had gained 20 lbs. and had no pain. He discontinued pancreatin, and his stools were copious, fatty and foul. On several occasions small stones were extruded from the fistula. Physical examination revealed only a pancreatic fistula. Glucose tolerance was 97, 134, 105, 100, 98 mg. per 100. Insulin tolerance was 100, 94, 72, 69, 101, 97 mg. per 100 of sugar in the blood. There was essentially no change in enzyme activity. Lipiodol study of the fistula showed opaque material extending toward the upper quadrant in a linear manner. On July 16, 1948, a left dorsal sympathectomy and splanchnic nerve section were done from the ninth dorsal segment to the diaphragm. Insulin tolerance 89, 69, 74, 69, 76, 86, and pancreatic enzyme activity remained unchanged. Pancreatic output was not measured. He was discharged July 26, 1948. When last heard of, he complained of mid-epigastric pain at the site of the external pancreatic fistula.*

Case 6.—Richard D., University of Illinois Clinic No. 340-977, a 33-year-old white tavern keeper was well until 1945, when he began to complain of epigastric pain which radiated through to the back. These pains came in a series of attacks generally about an hour after eating. The pain was quite severe and on occasion necessitated hypodermics for relief. He had no jaundice or clay-colored stools until an attack in 1947. At that time a celiotomy was performed at an outside hospital where a diagnosis of chronic pancreatitis with obstruction of the common duct was made. A cholecystogastrostomy was performed with relief of the jaundice; however, foul bulky stools, which had been present preoperatively, persisted. The pain which he had experienced was not relieved by the operative procedure, and he was controlled only with narcotics until August 1948, when he reported to another institution for examination. There a right splanchnic nerve section was performed with relief of the pain for about one month. The pain, however, recurred in approximately the same position on the opposite side and the midline, except that it did not radiate through his back. He also experienced episodes of nausea and vomiting accompanying these attacks of pain. He was admitted to the hospital for these symptoms. A light spinal anesthesia was performed during an attack while in the hospital, with complete relief of his symptoms. Roentgen ray examinations revealed numerous small areas of calcification in the region of the pancreas, which was considered consistent with a chronic pancreatitis. An upper gastro-intestinal series was essentially normal. Urinalysis showed no glucose or albumin. Hemoglobin 13.5 Gm.; hematocrit 44, red blood count 4,800,000, NPN 33, Co₂ 58, NaCl 511, total protein 6.1 with albumin 4.5, globulin 1.6, serum amylase 65 and 88, glucose 139 mg. per 100. Physical examination revealed some tenderness in the upper abdomen without spasm, rigidity or palpable masses during an attack. The tenderness was fairly well localized in the epigastrium. The examination was otherwise normal. On January 4, 1949, a left dorsal sympathectomy, removing the ganglia from the ninth through the twelfth dorsal segment as well as the major splanchnic nerve, was performed. Postoperatively, the patient did well and had complete relief of his preoperative pain, nausea and vomiting. He developed pain in his incision, however, which caused moderate discomfort. Routine urinalysis, following surgery, revealed 4-plus glycosuria; fasting glucose was repeated and was found to be 235 mg. per 100. On January 10, a glucose tolerance test (intravenous) gave the following: fasting, 190, 320, 286, 267, 229. On January 12, a glucose tolerance test gave the following: 220, 308, 267, 276, 258. Postoperatively, his serum amylase was slightly elevated, being 148 on the 6th, 213 on the 8th, and 189 on the 11th of January. The icteric index, serum bilirubin were normal. He also continued to have fairly large bulky stools. He was transferred to the medical service on the tenth postoperative day for management of his diabetes and apparent steatorrhea. At this time he was asymptomatic except for slight pain in his incision. On

* The fistula was implanted into the bowel in October, 1949, by Dr. J. T. Reynolds. He complained of no pain. The calcareous deposits had disappeared from the right side of the pancreas.

the medical floor his diabetes has been well controlled with 14 units of regular insulin and 10 units of protamine insulin each day. He was placed on a 2500 and 44-calory diet, which is considered basal plus 60; and the diet contained 284.6 Gm. of glucose. It is interesting to note that he has occasionally been home on pass from the medical service and during those periods has developed mild exacerbation of his nausea and vomiting without pain. When last examined, his abdominal pain had completely disappeared, and he had put on 10 pounds. Diabetes seemed stable but persistent.

Case 7.—This additional case has been brought to our attention by Dr. O. C. Julian, who supplied the following abstract from the Vascular Surgery Unit at Hines Hospital, Illinois: R. B. H., No. 220146, a 34-year-old accountant, had attacks of vague epigastric distress at the rate of about three a year, beginning in 1939. He sought medical advice in 1945 because these attacks had become more frequent and a continuous pain had been added. This continuous pain was in the right side of the epigastrium. It was dull in character and was distinctly aggravated by eating. The attacks of vague epigastric distress changed in character late in 1946. At this time they occurred weekly, lasting two or three days each time, and were characterized by paroxysms of colicky epigastric pain radiating to the right upper back and accompanied by nausea and vomiting. In 1948 pancreatic stones were found on roentgen ray. The patient was placed on pancreatin without improvement. There were no foamy or fatty stools at any time. He lost 32 pounds of weight. He was first seen in the Vascular Clinic in December, 1948, and gave the foregoing history.

Physical examination was essentially negative except for evidences of marked weight loss which the patient ascribed to his avoidance of eating because eating produced pain. There were no tender areas or masses within the abdomen. He required $\frac{1}{4}$ gr. of morphine 3 times a week. A splanchnic procaine block was done. The patient had immediate relief of the pain, lasting two and one-half hours. During the ensuing two weeks the symptoms returned and for this reason a right splanchnic section and excision of the tenth, eleventh, and twelfth dorsal ganglia was done on December 20, 1948.

The last follow-up examination was about March 1, 1949. The patient stated that since operation he had been relieved of all pain. His appetite had returned and he had gained 13 pounds. In the week before this examination he had started to have a little ache in the left side of the epigastrium, which had completely disappeared.

DISCUSSION

After our initial experience with Case 1, in which pain of pancreatic origin was due to cancer, we have purposely refrained from advocating or performing splanchnicectomy for carcinoma of the pancreas, since in addition to the visceral pain, mediated by the splanchnic nerves, the invasive lesion affects the peritoneum, the lumbar roots and their outflow, and thus pain-relief will be very temporary. Nevertheless, because of the uncertainty in Case 4, in which two experienced abdominal surgeons could not make a positive diagnosis of cancer, and in whom a histologic diagnosis of chronic fibrosing pancreatitis was obtained, another instance of pancreatic cancer was subjected to splanchnicectomy. Since the patient died shortly after a cholecysto-jejunostomy, this case must be excluded from the analysis of our results, which thus must be based on five patients suffering from chronic pancreatitis with intractable pain, necessitating increasing doses of narcotics. (Table I.)

Martin and Canseco² have made the point that surgical treatment offers the only means of relief. It is true that pancreatic extract by mouth is useful

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

for the diarrhea, and that a diminished sugar tolerance, or frank pancreatic diabetes as seen in our cases, need attention, but the inability to eat, the frequent bouts of vomiting due to reflex pylorospasm,³ produce a severe weight loss and the increasing intake of narcotics brings on addiction. For this reason, when the diagnosis of chronic sclerosing calcareous pancreatitis is made, early surgical relief from pain is advisable.

In the group reported by Martin and Canseco from Johns Hopkins University, five surgical methods were employed, namely: partial pancreatectomy,⁴

TABLE I.—*Splanchnic Nerve Section for Chronic Pancreatitis*

Case	Age	Weight Loss in Pounds	Daily Nar- cotic Intake	Splanchnic- ectomy	Pain Relief	Gain in Weight (Pounds)
J.A.W.	22	25	Pantopon gr. 3	Left	Complete 2 years	20
M.P.	43	55	Morphine gr. 1½	Right	Complete* 19 months	35
V.J.	36	15	Demerol 300 mg.	Bilateral	Complete†	18
R.D.	33	15	Demerol 300 mg.	Bilateral	Complete 6 months	10
R.B.	34	32	Morphine gr. ¼‡	Right	Complete 2½ months	13

* Two attacks of left-sided pain.

† One attack due to pancreatic retention cyst, 14 months.

‡ Three times a week.

total pancreatectomy,⁵ complete pancreatic denervation by sectioning both vagal and sympathetic fibers,⁶ pancreatotomy with removal of stone,⁷ and ligation of pancreatic ducts, which was their choice. In a case of chronic calcareous pancreatitis both the ducts of Santorini and Wirsung were tied off, but during the course of exploration numerous calculi were removed and release of pancreatic fluid was obtained which may have contributed to the relief of pain.

An analysis of the mortality and morbidity of total pancreatectomy would not seem to warrant its employment in benign lesions. Partial pancreatectomy, particularly left-sided pancreatectomy, is a far more benign procedure. It has been employed by Mallet-Guy ever since 1935, who described 34 cases in his monograph.⁸ Mallet-Guy felt that biliary drainage was useful in diffuse pancreatitis or in cases limited to the head of the pancreas. However, biliary infection and drainage did not seem to affect the tail of the pancreas, which he removed in five instances with four cures lasting for several years and one postoperative death. The same author, however, became impressed with the relief of left-sided splanchnic nerve sections, particularly in those cases where the sclerosing or calcareous lesion was not limited to the left side, and in a recent communication⁹ reported on 70 left splanchnicectomies for chronic relapsing pancreatitis done from the year of 1942 to 1948. These were done below the diaphragm, with a subperitoneal lumbar approach and

with one death. Of 37 patients, whose follow-ups extended from one to seven years, there were five failures, 21 excellent, seven very good and three good results. One patient died. The failures were mostly due to a hypertonus of the biliary tract, which should be drained externally or internally when compression or stenosis is demonstrable. He would only perform partial pancreatectomy now in case of failure of splanchnicectomy. One patient had a bilateral splanchnic section when the pain shifted to the right.

Our five cases of the benign, chronic relapsing variety allow some speculation as to the mechanism of relief obtained. In Case 2 it was most striking to see the immediate subsidence of persistent vomiting and upper abdominal distention. The arguments for the splanchnic nerves being the exclusive sensory afferents of the upper abdominal organs need not be repeated here.¹ Their interruption also explains the abolition of viscerovagal reflexes leading to biliary and pyloric spasms, which have been studied in connection with pulmonary embolism.¹⁰ Some authors, however, have expressed the opinion that an efferent, vasodilator effect may be beneficial on the vasoconstriction and edema which is an accompaniment of the acute or recurrent attack. Popper,¹¹ Marion¹² and Gage¹³ have seen acute attacks of pancreatitis subside after paravertebral or splanchnic block. MacKenzie and one of us,¹⁴ writing in 1932 on acute pancreatic necrosis, made the point that edema may proceed into hemorrhage or necrosis, and this has been confirmed experimentally by Popper and Necheles.¹⁵ They produced extensive pancreatic edema by ligation of the pancreatic duct and subsequent stimulation of pancreatic secretion by secretin. This edema can progress into necrosis. Such findings would make it doubtful that ligation of the pancreatic duct as advocated by Martin and Canseco² should be done for the relief of pancreatic pain, since it might activate an acute process, especially if pancreatic drainage is not available through pancreatotomy. But it might also explain a rapid alleviation of symptoms after sympathetic block if the edema has not progressed to extensive destruction.

One can block the paravertebral segments from the sixth to tenth dorsal level on the side of pain and obtain temporary relief. This was done as part of the preoperative study.

Interestingly, the fluctuating amylase values, which might be interpreted as symptoms of increasing and decreasing pancreatic inflammation, stabilized after splanchnic nerve section in Case 2. In Case 6 there seemed to be an exacerbation of the inflammatory process after splanchnicectomy, manifested by rising amylase values and a deterioration of sugar tolerance. Unfortunately, in this patient no preoperative sugar tolerances are available; however, his high tolerance curve may have a hepatic component because of his excessive alcoholic intake.

Gage¹³ suggested that sympathetic interruption relieves ductal and vascular spasm in the pancreas. That this may well be a factor is illustrated by a cholecystogram of Lena S., a patient whose history was described in our

first communication¹ and whose painful biliary colics became painless after bilateral splanchnicectomy undertaken for the relief of hypertension. The reflux of the dye into the pancreatic duct is very evident in this case. (Fig. 2.)

Mallet-Guy has emphasized in his writings,^{4, 8, 9} that the inflammatory sclerosis with its sensory nerve irritation sets up a reflex pain and spasm not unlike a causalgic state, and one of us has expressed the same idea in relation to certain post-cholecystectomy syndromes.¹⁶ Experimentally, Mallet-Guy produced pancreatic edema by stimulating the left splanchnic nerve with a weak current.¹⁷ While these various mechanisms may be all at play, the instant pain relief following procaine block or surgical section of the appropriate sympathetic pathways is an established fact in visceral pain of pancreatic origin.

While chronic pancreatitis may involve isolated segments of the gland, and thus permit a partial excision or unilateral splanchnicectomy, a follow-up of our patients would indicate that bilateral denervation may become necessary when the pain shifts over to the unoperated side. This is a thought expressed to us by Dr. James C. White¹⁸ and is analogous to the situation encountered in angina pectoris, when unilateral sympathetic denervation almost invariably has to be followed by operation on the opposite side.

Since splanchnicectomy on the right side increases biliary motility and since this may result in distention or pancreatic reflux in cases of common duct compression or stricture, it is possible, as Mallet-Guy points out, that the biliary tract should be decompressed prior to splanchnicectomy when a hypertonus exists. In the case of Vincent J. (Case 5), a huge pancreatic cyst had to be opened and marsupialized after splanchnic section, and while the mass in the head of the pancreas was present before operation, it seemed to grow rapidly afterwards. Since biliary reflux into the pancreas—when the anatomic conditions are suitable—is one of the factors in the production of pancreatic edema and necrosis, one wonders whether splanchnicectomy or splanchnic block, while it relieves pain and abolishes visceral reflexes, may not



FIG. 2.—Visualization of the biliary tract in the case of L. S. through the common duct. This patient had a painless obstructive jaundice following a dorso-lumbar sympathectomy and splanchnic nerve section. Note the metal clips along both sides of the spine. Note the reflux into the pancreatic duct, which occurs in about 20 per cent of the cases.

favor more biliary reflux. With pancreatic ducts obstructed by stone or inflammation, this possibility is not too great but cholecystograms and visualization of the biliary tree with pressure-measurements may call for internal biliary drainage before splanchnicectomy.⁸

Bilateral splanchnicectomy is a benign procedure. It carries about one per cent mortality in our hypertensive series of 400 patients. It is to be preferred to partial and total pancreatectomy, and to pancreatotomy and to duct-ligation. We believe that it will assume a standard place in the treatment of chronic sclerosing or calcareous pancreatitis accompanied by intractable pain.

Recently, Grimson, Hesser and Kitchin¹⁰ reported the removal of both celiac ganglia and of the superior mesenteric ganglion in a 33-year-old man suffering from calcareous pancreatitis. Following this operation pain was relieved for five months but recurred with severe attacks of back-pain and one attack of epigastric pain. This operation has the obvious advantage of allowing for abdominal exploration and section of visceral pain fibers at the same time. Whether it is superior to bilateral splanchnic nerve section remains to be seen. It seems probable that with a recent tendency to return to the abdomen from thoracic neurectomies (as in vagotomy for duodenal ulcer, sympathectomy for hypertension) more visceral neurectomies will be done through the abdomen, and this is what Mallet-Guy has advocated for pancreatitis. Our present experiences would favor a thorough abdominal exploration, a biliary side-tracking operation if necessary, and a retropleural section of visceral afferent fibers at a later date.*

SUMMARY

Seven patients are being reported in this series who underwent splanchnicectomy for pain of pancreatic origin. Of them two were suffering from inoperable carcinoma of the pancreas, and such patients do not obtain anything but temporary relief from the operation. The remaining five patients suffered from chronic calcareous pancreatitis and their response to the operation, as manifested by relief of pain and gain in weight, was excellent. Two out of four patients had bilateral splanchnicectomies and it seems likely that a certain group of patients, whose pancreatic involvement is diffuse, may have the second splanchnic nerve cut after the pain subsides and shifts from the dominant to the silent side. The state of the biliary tract should also be considered, since biliary reflux into the pancreas may occur under certain conditions. The operation done in these patients was a retropleural supra-diaphragmatic splanchnic nerve section and excision of the dorsal sympathetic chain from the ninth to the twelfth dorsal segments.

BIBLIOGRAPHY

- ¹ de Takats, G., and L. E. Walter: The Treatment of Pancreatic Pain by Splanchnic Nerve Section. *Surg., Gynec. & Obst.*, **85**: 742, 1947.

* Since this article was submitted for publication, Ray and Console (*Surg., Gynec. and Obst.*, **89**: 1, 1949) have reported conclusions identical with ours.

SPLANCHNIC NERVE SECTION FOR PANCREATIC PAIN

- 2 Martin, L., and J. D. Canseco: Pancreatic Calciosis. *J. A. M. A.*, **135**: 1055, 1947.
- 3 Lüdin, M.: Regionärer Gastrosasmus bei Pankreaserkrankung. *Act. Rad.*, **19**: 348, 1938.
- 4 Mallet-Guy, P., et M. Plauchu: Inflammation Chronique de la Queue du Pancreas, sequelles de Pancreatite Oedemateuse. *Pancreatectomie Partielle. Lyon Chir.*, **23**: 742, 1935.
- 5 Whipple, A. O.: Radical Surgery for Certain Cases of Pancreatic Fibrosis, Associated with Calcareous Deposits. *Ann. Surg.*, **124**: 991, 1946.
- 6 Rienhoff, W. F., and B. M. Baker: Pancreolithiasis and Chronic Pancreatitis. Preliminary Report of a Case of Apparently Successful Treatment by Transthoracic Sympathectomy and Vagotomy. *J. A. M. A.*, **139**: 20, 1947.
- 7 Eliason, E. L., and R. F. Welty: Pancreatic Calculi. *Ann. Surg.*, **127**: 150, 1948.
- 8 Mallet-Guy, P., et A. Vachon: Pancreatites Chroniques Gauches. 1943, Masson et Cie., Paris.
- 9 Mallet-Guy, P., et M. Jaubert de Beaujeu: Treatment of Chronic Pancreatitis by Unilateral Splanchnicectomy. To be published.
- 10 de Takats, G., W. C. Beck and G. K. Fenn: Pulmonary Embolism. *Surgery*, **6**: 339, 1939.
- 11 Popper, H. L.: Die Paravertebrale Nervenausschaltung bei Pankreatitis. *W. Kl. Wochschr.*, **44**: 998, 1931.
Paravertebrale Injection bei Pankreatitis. *Zblatt f. Chir.*, **60**: 2050, 1933.
- 12 Marion, P.: Sur le Traitement des Pancreatites Aigues par les Infiltrations Splanchniques. *Lyon Chir.*, **40**: 315, 1945.
- 13 Gage, M.: Treatment of Acute Pancreatitis with Report of Cases. *Trans. of South. Surg. Assn. Surgery*, **23**: 723, 1948.
- 14 de Takats, G., and W. D. MacKenzie: Acute Pancreatic Necrosis and Its Sequelae. *Ann. Surg.*, **96**: 418, 1932.
- 15 Popper, H. L., and H. Necheles: Edema of the Pancreas. *Surg., Gynec. & Obst.*, **74**: 123, 1942. Transition of Pancreatic Edema Into Pancreatic Necrosis. *J. of Lab. and Clin. Med.*, **32**: 1528, 1947.
- 16 de Takats, G., Discussion of Article: N. A. Womack and R. L. Crider: The Persistence of Symptoms Following Cholecystectomy. *Ann. Surg.*, **126**: 840, 1947.
- 17 Mallet-Guy, P., R. Jeanjean et J. Feroldi: Provocation Experimentale de Pancreatites aigues par Excitation Electrique du Splanchnic Gauche. *Lyon Chir.*, **39**: 437, 1944.
- 18 White, James C.: Personal Communication.
- 19 Grimson, K. S., F. H. Hesser and W. W. Kitchin: Early Clinical Results of Transabdominal Celiac and Superior Mesenteric Ganglionectomy, Vagotomy or Transthoracic Splanchnicectomy in Patients with Chronic Abdominal Visceral Pain. *Surgery*, **22**: 230, 1947.

BILATERAL SPLANCHNICECTOMY AND LUMBODORSAL SYMPATHECTOMY FOR CHRONIC RELAPSING PANCREATITIS*

JOHN E. CONNOLLY, M.D., AND VICTOR RICHARDS, M.D.

SAN FRANCISCO, CALIFORNIA

FROM THE DEPARTMENT OF SURGERY OF THE STANFORD UNIVERSITY SCHOOL OF MEDICINE
AND THE STANFORD UNIVERSITY HOSPITALS, SAN FRANCISCO

INTRODUCTION

IN 1945 MALLET-GUY, JEANJEAN, AND SERVETTAZ¹ reported a small number of cases of chronic pancreatitis treated by unilateral splanchnicotomy. This was followed by reports in the French literature by Marion² and Reyes³ of good results in treating the painful acute attack of pancreatitis with procaine block of the splanchnic nerves.

Following this work a number of American investigators have reported on their experience with this new approach to the problem of relieving the pain of chronic pancreatitis before the victim of the disease falls prey to opiate addiction.

Comfort, Gambill, and Baggenstoss⁴⁻⁶ have in the past two years popularized the term chronic relapsing pancreatitis with two excellent articles comparing two series of cases, one of chronic relapsing pancreatitis associated with biliary tract disease and the other chronic pancreatitis free of concomitant biliary tract disease. They describe this syndrome as merely a series of acute attacks of pain separated by varying amounts of time, or continuous, in either eventuality leading to the complications of steatorrhea, calcification and diabetes. Until recently the available therapy for these unfortunate people, especially those who have the syndrome without associated biliary tract disease, has not been entirely satisfactory. In the cases associated with cholecystitis or cholelithiasis as revealed by cholecystography, removal or drainage of the diseased portion of the biliary system provides satisfactory results in a certain number of patients. But for the patient with chronic relapsing pancreatitis without concomitant biliary tract disease, the available measures such as ligation of the pancreatic ducts, removal of calculi in the ducts,⁷ or partial to complete pancreatectomy⁸ have been unsatisfactory, either because of poor therapeutic results or because of the associated high operative mortality.

SUMMARY OF REPORTS OF OTHER INVESTIGATORS

Rienhoff⁹ is apparently the first American investigator to report a case of splanchnic section and sympathetic denervation for chronic pancreatitis. He removed the sympathetic chain transthoracically from the fifth dorsal to the second lumbar ganglia bilaterally, and performed also bilateral vagectomy in

* Submitted for publication January, 1949.

two separate procedures. Eight months following operation the patient continued to be greatly improved.

Smithwick¹⁰ reported a good six month result in 1946 following a right-sided transthoracic resection of the sympathetic trunk from the third to the twelfth thoracic vertebrae, and the corresponding splanchnic chain, in a patient with intractable chronic relapsing pancreatitis.

deTakats¹¹ in 1947 reported two cases for which he performed unilateral splanchnic resection and dorsal sympathectomy from the ninth to the twelfth thoracic ganglia through a modified Smithwick approach, removing the eleventh rib. One was for intractable pain in a patient with inoperable carcinoma of the pancreas, the result being relief from pain for only three weeks. The operation was not then carried out on the other side because the recurrent pain was said to be on the denervated side. In the second case a similar procedure was performed in a patient with chronic relapsing pancreatitis with calcification. The result was still excellent at the time of the writing of the article six months later. If pain should recur, the authors state that they would perform the same procedure on the opposite side.

McDonough and Heffernon¹² report very satisfactory results following lumbodorsal sympathectomy from the fifth thoracic to the second lumbar vertebrae and splanchnicectomy in three case of chronic relapsing pancreatitis treated at the Lahey Clinic up to June 1948.

Most of the above procedures were somewhat at variance with the conclusions reached by Ray¹³ in his careful study on abdominal visceral sensation in man. In his reported studies he: (1) found that splanchnicectomy and sympathectomy of the seventh dorsal to the third lumbar ganglia is sufficient to denervate completely visceral sensation from the pancreas; (2) expresses the combined opinion of many investigators that the vagi nerves do not carry visceral pain fibers, and (3) that the pancreas has a bilateral innervation for afferent pain fibers and draws the conclusion that a bilateral nerve section is necessary to denervate completely the pancreas from pain fibers. He does not specifically state how much of the sympathetic chain must be removed with the splanchnic nerves but implies that it is not more than from the seventh dorsal to the third lumbar ganglia.

Stimulated by the foregoing papers and by the simultaneous appearance of two patients with intractable pain from chronic relapsing pancreatitis, we became interested in a new technical approach to this problem. It seemed apparent from the previous case reports and from Ray's work that in order to denervate completely the pancreas a bilateral section of the splanchnic nerves and of the corresponding sympathetic chains would be necessary. This was performed as for sympathectomy and splanchnicectomy for hypertension by employing a modified bilateral one stage Peet operation.¹⁴ This operation differs from Peet's procedure in that a portion of the twelfth as well as the eleventh rib is removed, facilitating the peeling of a portion of the crus of the diaphragm away to allow excision of the sympathetic chain below the first

lumbar ganglion. The greater, lesser and least splanchnic nerves are excised, together with the sympathetic chain from the seventh or eighth thoracic ganglia to the second lumbar ganglia. Our operative time with two teams working simultaneously averages about one hour.

We favor this procedure for the following reasons:

1. It is an operation of less magnitude than the Smithwick type of procedure.
2. It is a one stage procedure which completely denervates the pancreas of pain fibers.
3. Its extent is adequate to denervate the pancreas as verified by Ray's work and our experience in two cases.

CASE REPORTS

Case 1.—SC No. 281342. J. S., a white male, 40-year-old pile driver, entered Stanford University Hospital on September 21, 1948, with a diagnosis of carcinoma of the head of the pancreas. Briefly his story was as follows:

Although an habituated alcoholic he had been in good health until 18 months prior to entry. At that time he noted the gradual onset of constant burning epigastric pain. It was fairly well controlled by aspirin until 15 months before entry or three months after the initial symptoms when there developed an acute epigastric pain so severe as to necessitate opiates and admission to the Permanente Hospital in Oakland, California. After several days of observation, abdominal exploration was performed and evidence of acute pancreatitis found. He recovered from this attack but never was free of the former constant burning pain in the midepigastrium.

Three similar exacerbations requiring hospitalization for a week or two followed at two to three month intervals. The fourth and most severe attack was approximately four months before admission. Upon hospitalization in a small Washington State mining town this fourth time he was again explored and was found to have a firm mass occupying the head of the pancreas. Its size was described as that of an English walnut. The surgeon thought he was dealing with carcinoma of the head of the pancreas and advised the patient to consult a center where the radical Whipple type of operation could be carried out. Gastro-intestinal and gallbladder films had been found negative prior to admission.

On admission here it was found that his weight had increased between attacks and that there was no history of nausea, vomiting or chills.

Physical examination disclosed a very healthy appearing male in no acute distress but complaining of a constant dull epigastric pain. There was no jaundice, the only abnormal finding being moderate tenderness just to the right of the midline, high in the epigastrium.

Although the blood amylase studies were normal, the stools not markedly abnormal in fat content, the fasting blood sugar normal and the flat plate of the abdomen negative for pancreatic calcuosis, a diagnosis of chronic relapsing pancreatitis was made.

Forty-eight hours after admission the patient experienced an exacerbation of his epigastric pain much like that at the beginning of the previous attacks. In order to test the effect of splanchnicectomy and sympathectomy, 30 cc. of 0.5 per cent novocaine solution was injected bilaterally just above the twelfth rib as advocated by Gage for acute pancreatitis. He experienced immediate complete relief of pain but only for six hours. In view of the promising result a second such paravertebral block was carried out with complete relief still present 13 hours after injection at which time operation was performed. On September 25, 1948, a bilateral Peet splanchnicectomy and sympathectomy modified as previously stated was carried out by two teams. When entering

CHRONIC RELAPSING PANCREATITIS

the chest the tenth and eleventh intercostal nerves were cut. The patient withstood the procedure well with the blood pressure never falling below 100/70.

The postoperative course was uneventful except for severe radicular pain along the courses of the cut intercostal nerves. He was discharged from the hospital on October 10, 1948, and continued to have decreasing amounts of radicular pain for two months. Over nine months have passed now since operation without any recurrence of his former constant burning epigastric pain.

Case 2.—SC No. 278607. Mrs. V. F., white, 36-year-old housewife with an alcoholic history, entered Stanford University Hospital on July 24, 1948, for the first time. For four years she had had recurring bouts of severe epigastric pain radiating through to the back associated with marked vomiting and a weight loss of 50 pounds. One year before entry a diagnosis of acute cholecystitis was made and an exploratory laparotomy in Dunsmuir, California, revealed that the gallbladder was normal but that the pancreas was large and firm and contained an abscess in the region of the head. A biopsy revealed fibrosis and chronic inflammation. Postoperatively the patient continued to have recurring fever with vomiting, and because of her downhill course she was referred to Stanford University Hospital.

Physical examination disclosed a slightly jaundiced, thin female, complaining of constant gnawing epigastric pain. T. 103, p. 126, r 24, b.p. 126/84. A No. 15 French catheter protruded from the corner of a well-healed left upper quadrant incision. There was some slight tenderness in the right flank on deep palpation. A slight amount of clear fluid occasionally drained from the catheter. W. B. C. 7800, R. B. C. 4,700,000. Icterus index was 40. Chlorides 487 mg. per 100. The blood amylase was within normal limits. The catheter drainage was reported to contain amylase. Cephalin flocculation was 2 plus, bilirubin 4.8 mg. per 100 direct and 6.9 mg. per 100 total.

Fluids were administered parenterally, and in several days the temperature returned to normal, the drainage stopped and the catheter was removed. A flat film of the abdomen demonstrated diffuse calcification of the pancreas. Again a diagnosis of chronic relapsing pancreatitis was made. She was discharged on July 31, 1948, to return in two months for pancreatectomy, in the hope that in the meantime she would recuperate some strength and weight.

However, at home the patient had an exacerbation of her epigastric pain and lost 11 pounds. She re-entered the University Hospital on September 19, 1948, for consideration of operative therapy. There was no icterus, and otherwise the examination was the same as on the first admission two months previously. The icterus index was 15 and the plasma proteins 6.2 mg. per 100.

Although pancreatectomy was originally planned for this patient, a splanchnicectomy was now considered an appropriate procedure for her recurring pain, particularly in view of her debilitated state. A block of the splanchnic and sympathetic fibers was carried out by the injection of 30 cc. of 0.5 per cent novocaine solution bilaterally paravertebrally just above the twelfth ribs. The patient had immediate relief of pain lasting approximately five hours. Accordingly, a bilateral splanchnicectomy and lumbo-dorsal sympathectomy was performed on September 28, 1948.

Her postoperative course was complicated by difficulty in curtailing narcotics to which she had become accustomed for so long. The fact that it was possible to discontinue all opiates two weeks after surgery demonstrates the absence of her former constant epigastric distress. Ten weeks after operation the patient was not using narcotics and continued to have relief from her former constant severe abdominal pain; however she still complained of intercostal neuralgia. Unfortunately this patient moved from her former home and we have been unable to obtain a more recent follow-up on her present condition.

DISCUSSION

In presenting this operative therapy we realize that the approach to the problem of chronic pancreatitis by section of the involved pain-carrying fibers may not be the most desirable and physiologic solution. Popper¹⁵ and Reyes,³ however, believe that the operation has a direct effect on the inflammatory process and on the vascularity of the gland, thus supplying a direct therapeutic effect. We believe it offers promise of being more satisfactory than other available measures in the handling of the patient with severe chronic relapsing pancreatitis for whom relief of pain must be afforded, else opiate addiction may occur.

As with sympathectomy for hypertension, we acknowledge the objection that visceral nerve section may be of severe consequence because it destroys the warning signal of impending surgical emergencies, such as a perforated ulcer or gallbladder. Interestingly enough, those who have had the opportunity to follow large series of sympathectomies have not noted severe consequences following upper abdominal surgical emergencies. The sensory fibers innervating the peritoneum are still intact and are ever present to warn us of impending perforation.

It has been stated in the literature that bilateral excision of the first and second lumbar ganglia usually destroys the power of ejaculation in the male. Although we have performed this operation only once in a male patient for chronic pancreatitis, we have employed exactly the same operative procedure on over a hundred patients for hypertension and advanced glomerulonephritis,¹⁴ many of these being young males, with the majority having only temporary difficulty with ejaculation. Even if the risk of sterility was greater than our experience has been, we feel that splanchnicectomy is indicated to relieve the intractable pain of the patient with chronic relapsing pancreatitis.

We consider the use of splanchnicectomy in chronic relapsing pancreatitis much as we do sympathectomy for vascular disease. We may not be attacking the underlying etiology of the disease, but we are providing a means of relief in a disease which demands some therapy in its chronic relapsing form. Until we are able to prevent the occurrence of vascular disease or of pancreatitis we feel justified to offer the unfortunate victim of either disease the potential relief obtained by sympathectomy and splanchnicectomy.

SUMMARY

1. A brief summary of the literature to date on the new concept of splanchnicectomy in the therapy of chronic relapsing pancreatitis is presented.
2. A bilateral one stage modified Peet supradiaphragmatic splanchnicectomy and lumbodorsal sympathectomy is advised because it is simpler and less hazardous and provides complete denervation of the pancreas in one operation.
3. Two case histories in which this technic of splanchnic section was employed are reported with good short follow-up results.
4. Acknowledgement is made that splanchnicectomy may not be the most desirable physiologic approach to the problem, but it is believed that it pro-

vides the best available means of dealing with a problem that demands some measure of relief in its chronic relapsing form.

BIBLIOGRAPHY

- ¹ Mallet-Guy, P, R. JeanJean, and P. Servettaz: Distant Results in the Treatment of Chronic Pancreatitis by Unilateral Splanchnicectomy. *Lyon Chir.*, **40**: 293, 1945.
- ² Marion, P.: The Treatment of Acute Pancreatitis by Infiltration of the Splanchnic Nerves. *Lyon Chir.*, **40**: 315, 1945.
- ³ Reyes, H.: Acute Pancreatitis and Splanchnic Block. *Arch. Soc. Cir. Hosp.*, **15**: 723, 1945.
- ⁴ Comfort, M. W., E. E. Gambill and A. H. Baggenstoss: Chronic Relapsing Pancreatitis. A Study of 29 Cases without Associated Disease of the Biliary or Gastro-intestinal Tract. *Gastroenterology*, **6**: 239, 1946.
- ⁵ Symposium by Staff Members of the Mayo Clinic: Chronic Relapsing Pancreatitis. *Proc. Staff Meet. Mayo Clinic*, **22**: 550, 1947.
- ⁶ Gambill, E. E., M. W. Comfort and A. H. Baggenstoss: Chronic Relapsing Pancreatitis. A Study of 27 Cases with Associated Disease of the Biliary or Gastro-intestinal Tract. *Gastroenterology*, **11**: 1, 1948.
- ⁷ Martin, Lay, and J. D. Causeco: Pancreatic Calculosis. *J. A. M. A.*, **135**: 1055, 1947.
- ⁸ Whipple, A. O.: Pancreatectomy for Chronic Pancreatitis. *Ann. Surg.*, **124**: 1006, 1946.
- ⁹ Rienhoff, W. E., and B. M. Baker: Pancreolithiasis and Chronic Pancreatitis: Preliminary Report of a Case of Apparently Successful Treatment by Transthoracic Sympathectomy and Vagotomy. *J. A. M. A.*, **134**: 20, 1947.
- ¹⁰ Smithwick, R. H.: Discussion of Paper of A. O. Whipple. *Ann. Surg.*, **124**: 1006, 1946.
- ¹¹ deTakats, Geza, and L. E. Walter: The Treatment of Pancreatic Pain by Splanchnic Nerve Section. *Surg., Gynec. & Obst.*, **85**: 742, 1947.
- ¹² McDonough, F. E., and E. W. Heffernon: Chronic Relapsing Pancreatitis. *Surgical Clinics of N. A.*, p. 733, June, 1948.
- ¹³ Ray, B. S., and C. L. Neill: Abdominal Visceral Sensation in Man. *Ann. Surg.*, **126**: 709, 1947.
- ¹⁴ Reichert, F. L., V. Richards, E. F. Holman, A. L. Bloomfield, T. Addis, D. A. Rytand and J. K. Lewis: The Medical and Surgical Treatment of Hypertension. To be published.
- ¹⁵ Popper, H. L.: Paravertebrale Injektion bei Pankreatitis. *Zbl. Chir.*, **60**: 2050, 1933.

RECONSTRUCTIVE SURGERY FOLLOWING RADICAL OPERATION FOR MALIGNANT TUMORS OF THE HEAD AND NECK*

HERBERT CONWAY, M.D.

NEW YORK, N. Y.

IN FORMER YEARS the serious objection to radical surgical excision of malignant tumors of the head and neck has been the extensive and frequently unmanageable deformity created by this treatment. Even after the development of the latex prosthesis, the unfortunate patient who was pronounced a clinical tumor cure, was faced with segregation by society as a facial cripple. The prostheses were inadequate in function, unnatural in appearance. They required special care and frequent replacement. Reconstructive surgery following clinical cure of tumors of the face was limited for years to the use of the free skin graft.

In the therapeutic contest between radiation and surgery for the treatment of cancer of the head and neck, this factor presented forceful argument. The unhesitant approach of military surgeons during World Wars I and II to the management of major problems of reconstruction of battle injuries demonstrated that only the very occasional patient need now wear an external facial prosthesis. This application on a large scale of the principles of reconstructive surgery established many years earlier, has been rewarded by the effective rehabilitation of those who might have been disabled completely by reason of facial disfigurement or dysfunction. It is the same resourceful approach in the management of malignant lesions of the head and neck which has effected the transfer of an increasingly higher percentage of cases of malignancy of the head and neck from the field of radiation therapy to the field of treatment by radical surgery. Principles of reconstruction, applied from the moment that surgical excision is decided upon, are utilized toward the goal of complete rehabilitation of the patient. The thought seems to be sound that, in today's intense attack upon cancer, the patient with a malignant tumor of the head and neck is left in an unfinished state unless the reconstructive surgery be carried through to a successful conclusion. Not all patients with malignant tumors of the head and neck are in the older decades of age; nor is the fact that a patient has lived three score and ten or more years justification for the fallacy that his facial reconstruction is unimportant. A plea, then, is made for the exercise of the methods and principles of reparative surgery at the time of the primary radical excision. Also, the feeling is expressed that too long a period of observation for recurrence of tumor is costly in absence from commercial or social pursuit, and is unjustified. Many patients who abhor the thought of surgical excision of a facial tumor involving bone will give consent

* Read before the joint meeting of New York Surgical Society and the Philadelphia Academy of Surgery, held in New York City, March 9, 1949. Submitted for publication April, 1949.

for such procedure readily if offered a plan for continued care until reconstruction is complete and acceptable.

The principles involved in radical excision of malignant tumors of the face are as follows:

1. Generous estimate of the amount of tissue to be removed with the tumor.
2. Placement of incisions parallel to the lines of elasticity of the skin when possible.
3. Unhesitant sacrifice of important anatomic structures in the neighborhood of the tumor.
4. Resection of regional lymph nodes if involved.

With a view to final reconstruction, the surgeon should:

1. Close all wounds by the suture of mucous membrane to skin or by the use of temporary thick-split grafts of skin.
2. Pay attention to the fixation of jaw fragments by intermaxillary wiring (by external splint or by intramedullary splint) so that unnecessary contraction of muscles does not occur.
3. Utilize primary flaps of regional tissue or outline flaps for reconstruction at the time of the radical excision.

In the final reconstruction, the plastic surgeon may utilize the following:

1. Free grafts of skin, derma, fascia, cartilage or bone.
2. Pedicled flaps from neighboring tissues or from a distant site.
3. Plates of foreign material, such as vitallium, tantalum or polyethylene.

Recent additions to these methods include the use of diced cartilage¹ for filling out a concavity and the use of composite free grafts of skin and cartilage from the ear.^{2, 3} Attention to color match of the transplanted skin surface is important to the rehabilitation of the patient. This can be accomplished successfully by the intradermal injection of insoluble, flesh-colored pigments (tattooing).⁴

Cases* to illustrate various points in reconstruction follow. Cases 1 and 2 illustrate the methods at command to meet the problem of color match of skin grafts on the face. In Case 1, the defect after excision was small enough that a graft of sufficient size could be obtained from the retro-auricular area, the skin of which matches the color of the skin of the face very well. Another source for grafts of somewhat larger size is the supra-clavicular area. Because of the scar produced at this donor site, this area is used as a source of grafts only in men. In Case 2, a thick-split skin graft measuring 10 by 5 cm. had been taken from the abdomen and transplanted to the forehead. The pale grey color of

* Cases were selected from the Surgical Service of the New York Hospital and from the Plastic Surgery Service of the U. S. Veterans Hospital, Bronx, N. Y. In the majority of these cases, the primary excision of tumor was done by the author; in some cases it was done by Dr. David Pinks of the U. S. Veterans Hospital or by members of the staffs of the New York Hospital and of Memorial Hospital, New York City, who referred the patients for reconstructive surgery. Credit is given to them as well as to the Resident Plastic Surgeons of the New York Hospital and the U. S. Veterans' Hospital, Bronx, N. Y., who carried out or assisted with the steps in reconstructive surgery.

the graft in contrast with the ruddy complexion of the patient's face constituted a significant deformity. The intra-dermal injection of flesh-colored pigments (tattooing) brought the color of this graft to an ideal match with that of the surrounding facial skin.

Case 1.—J. R., N. Y. H., No. 197,979. *Recurrent hair matrix carcinoma of skin of eyelid; single stage excision and repair by whole-thickness free graft of skin from retro-auricular area; satisfactory color match; no evidence of disease ten years later.* This man was seen for the first time in 1938 when he was 74 years old. A superficial tumor of the left lower eyelid had been removed in 1913. In 1937, the lesion recurred. Examination showed a papillary, crusted lesion of the left lower eyelid measuring 2.5 by 1.5 cm. in size. On April 1, 1938, the tumor was excised. The wound was closed by the use of a free



FIG. 1.—Thick split graft of the entire forehead applied after excision of multiple basal cell carcinomata. The portion over the right eye has been tattooed to effect color match to the surrounding skin. This area is sharply demarcated from that portion of the graft over the left eye which has not been tattooed at the time of this photograph (Case 2).

whole-thickness graft of skin cut from the right post-auricular region. Soon after removal of the dressings it was apparent that the color of the graft matched that of the surrounding skin very well. Microscopic examination of the specimen showed that it was a hair matrix carcinoma. The patient was examined in the Follow-Up Clinic of the New York Hospital in December, 1948, ten and one-half years after operation. There was no recurrence.

Case 2.—M. M., N. Y. H., No. 405,873. *Multiple basal cell carcinomata of forehead recurrent after roentgen ray therapy; complete excision of skin of forehead and replacement by thick-split graft; color match by tattooing.* This 64-year-old woman had changes

MALIGNANT TUMORS OF HEAD AND NECK

in the skin of her forehead for the previous 20 years. Roentgen ray therapy had been given over a period of 4 years. Examination showed a fungating tumor 3 by 4 cm. in size over the central forehead. Scaly plaques were apparent in the satellite area. The excision (1945) left a defect of the entire area of the forehead. Microscopy revealed basal cell carcinoma. Thick-split skin graft taken from the abdomen was applied. The light color of the graft contrasted sharply with the ruddy facial complexion of the patient. Two tattoo treatments brought the color of the skin graft to an accurate match with that of the face (Fig. 1).

The next report (Case 3) is an example of the use of a large rotation flap of scalp for the closure of an extensive wound created by carcinoma invading the skull and dura mater. In the management of locally invasive tumors such as this one, a plan for the closure of an extensive wound takes the tumor from the classification of inoperable and places it in the operable group.



FIG. 2.—(A) Recurrent carcinoma arising in the parotid gland and invading the skull and dura mater. Removal of the tumor necessitated excision of a wide area of scalp, the external ear, a portion of the temporal, parietal and mastoid bones and a section of underlying dura mater. The seventh nerve necessarily was sacrificed. Closure was by rotation of a large flap of scalp measuring 14 by 15 cm. (B) The site from which the flap was elevated was surfaced with a thick split graft (Case 3).

Case 3.—M. C., N. Y. H., No. 370,040. *Recurrent carcinoma invading skull and dura; excision and closure by rotation of large scalp flap.* This 66-year-old lady first noted a swelling in the left parotid gland in 1944. This was excised. Microscopy revealed "carcinomatous changes in a mixed tumor of the parotid." During March of 1944, roentgen radiation in the amount of 3300 R units was given to the left parotid region. In July, 1946, a recurrent tumor in the same area was excised and skin graft was applied. In July, 1948, there was another recurrent tumor behind the ear. The auricle, the external ear

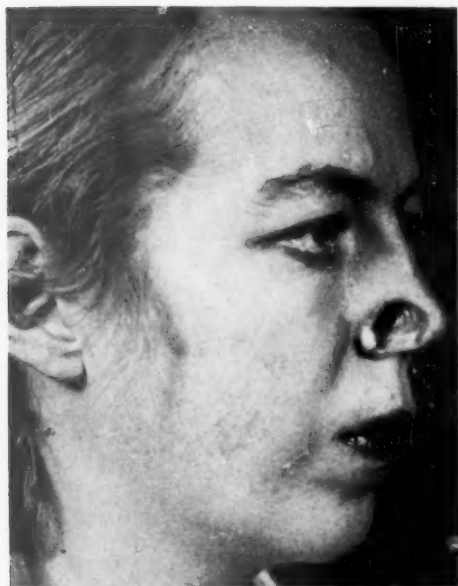
canal, the middle ear and the entire parotid gland were excised and skin graft was applied. This operation, too, met with failure. In November 1948, there was a nodular growth just over the mastoid bone. At this time, radical excision of the entire cranial parietes with temporal and mastoid bones and a section of invaded dura mater was carried out by Doctors Herbert Parsons and Charles Neumann. Closure was by rotation anteriorly of a flap of occipital scalp measuring 12.5 cm. in transverse dimension. The site from which the flap had been elevated was covered with a free thick-split graft of skin (Fig. 2, a and b).

Partial loss of the external ear created by excision of tumor may be corrected effectively by the use of local flaps. If a sizeable portion of the helix must be sacrificed, the use of a free graft of cartilage or some supporting, inert material is necessary. The combination of excision and first stage reconstruction at the first operation diminishes the period of time in the hospital and the period of morbidity. After excision of the carcinoma, the field is redraped, the operating team dons new gowns and gloves and a new set of instruments is used. These precautions are taken in order to prevent the transplantation of carcinoma to the donor site. Case 4 is an example. If it is necessary to sacrifice the entire ear, reconstruction cannot be effected, and the patient has recourse only to the use of a latex prosthesis.

Case 4.—J. M., U. S. Vet. Hosp., No. 94,904. *Squamous cell carcinoma of the ear; excision and reconstruction by tantalum wire mesh and free skin graft.* This 60-year-old man noted a growth on his ear 15 years before he requested treatment. Examination in May of 1947 showed a cornified, elevated lesion 1 cm. in diameter extending at right angle to the surface of the skin of the anterior aspect of the antihelix of the ear. There was no cervical adenopathy. On May 14, 1947, the middle one-third of the ear was excised. The upper and lower segments of auricle were sutured down in situ to the skin of the post-auricular and mastoid areas. At a second operation 3 weeks later, a patterned piece of tantalum wire mesh was inserted under the skin intervening between the two portions of the ear. Three weeks later, this central area of skin, subcutaneous tissue, and tantalum mesh was elevated from the side of the head. The V-shaped retro-auricular wound was surfaced by a free thick-split graft of skin. There has been no recurrence in the two years since operation, and the restoration of the ear is quite acceptable.

Small defects of the ala, the columella or the tip of the nose are very noticeable facial deformities. These are now corrected effectively by the use of free composite grafts of skin and fat² or of skin and cartilage taken from the ear.³ In Case 5, this method, introduced by Brown *et al.*,² was used. The burden of the introduction of circulation into these composite grafts is such that rarely are they successful if greater than 1 by 1 cm. in size. For larger partial defects of the nose, a temporal flap may be used for reconstruction. This flap can be transplanted as early as 14 days after its primary elevation, since the pedicle harbors the temporal artery and vein. An example is Case 6. Though the pedicle is replaced in its original position and the defect of the forehead, representing the original home of transplanted tissue, is covered by a whole-thickness free graft with acceptable final appearance, many patients, especially women, object to the use of this type of flap. In such instances, as in Case 7,

an arm flap or tubed pedicle may be used effectively. The use of the arm as a donor site has the disadvantage that the shoulder and elbow joints are immobilized necessarily during the three to four week period of migration from arm to nose. Complete amputation of the nose is necessary in the treatment of carcinoma more often than surgeons have the boldness to do it. Possibly this situation exists because of the dissatisfaction of patients who have had to wear prosthetic noses. Case 8 demonstrates total rhinoplastic reconstruction by use of an abdominal flap, migrated via the wrist.



A



B

FIG. 3.—(A) Defect of the nose after excision of squamous cell carcinoma. This defect was diminished in size by the rotation of a flap of skin downward and covering it with a whole-thickness graft of skin. (B) At a second operation the residual defect was corrected by the use of a composite graft of skin and cartilage taken from the nose (Case 5).

Case 5.—R. G., N. Y. H., No. 459,329. *Squamous cell carcinoma of ala of nose; reconstruction by rotation flap of skin and by composite free graft of skin and cartilage from the ear.* This patient was referred from Memorial Hospital in 1946, at the age of 36 years. In April of that year, Dr. Daniel Catlin had excised a squamous cell carcinoma, Grade I, from the skin of the right ala. The tumor was 2 cm. in diameter and operation extended to and involved the mucosa of the right nostril. Lesion was recurrent following roentgen ray therapy. Full thickness removal of the alar tissues was done. At the New York Hospital in October, 1946, an attempt was made to correct the defect by rotation inferiorly of a flap of skin from the right side of the nose and covering the area with a whole-thickness graft of skin. This procedure minimized the deformity but still left a

notched defect of the ala. This was corrected in April, 1948, by the use of a free composite graft of cartilage and skin taken from the ear. The patient has remained free from disease in the three-year period since operation (Fig. 3).

Case 6.—B., U. S. Vet. Hosp., No. 109,432. *Basal cell carcinoma of nose recurrent after roentgen ray therapy; radical excision and reconstruction by temporal flap.* This patient, a man of 59 years, received 3200 R units of roentgen ray in 1938 in the treatment of a basal cell tumor of the side of the nose. Recurrence in 1942 was treated by cautery excision. The patient did not report back to the hospital until 1948. In November, 1948, a flap incorporating temporal artery and vein was constructed and transferred to the nose. The pedicle was replaced and a thick-split graft was applied to the forehead.

Case 7.—N. W., N. Y. H., No. 434,950. *Plexiform epidermoid carcinoma of nose; radical excision; reconstruction by tubed pedicle from arm.* This white man, 64 years old, related that he noted a warty growth on the skin of his nose, just over the right ala, in

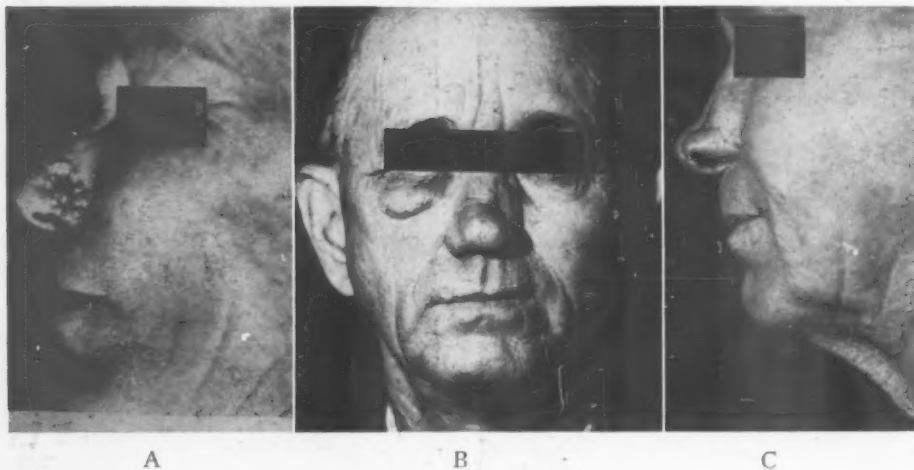


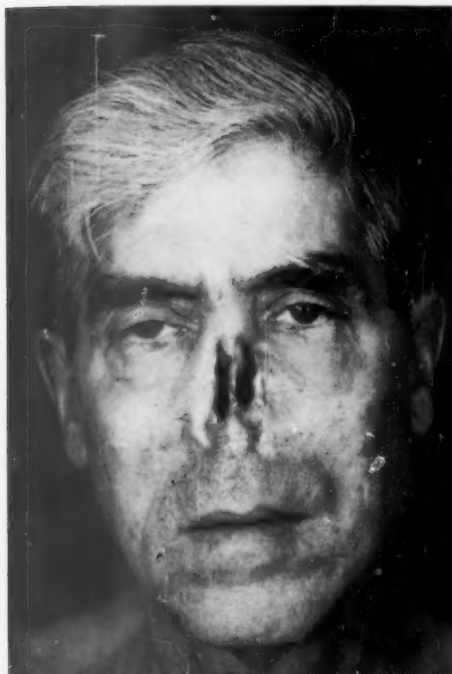
FIG. 4.—(A) Plexiform epidermoid carcinoma of the nose. (B and C) Appearance after reconstruction by means of a tubed pedicle from arm (Case 7).

1922. Ulceration of the growth occurred in 1934. There was no therapy until January, 1946, when the patient was admitted to the New York Hospital. Examination showed an ulcerated, indurated lesion 2 cm. in diameter over the right side of the nose. There was no cervical adenopathy. Radical excision, removing tumor, skin, cartilage and mucous membrane was done on February 15, 1946. Four days later, a tubed pedicle was fashioned on the antero-medial aspect of the right arm from a flap of tissue measuring 5 by 15 cms. On March 26, 1946, the tubed pedicle was divided at one end and sutured into the defect of the nose. The tubed pedicle was divided from the arm subsequently. Final revision was done on July 30, 1946. The appearance of the patient was satisfactory. This patient failed to respond to requests for follow-up examination (Fig. 4).

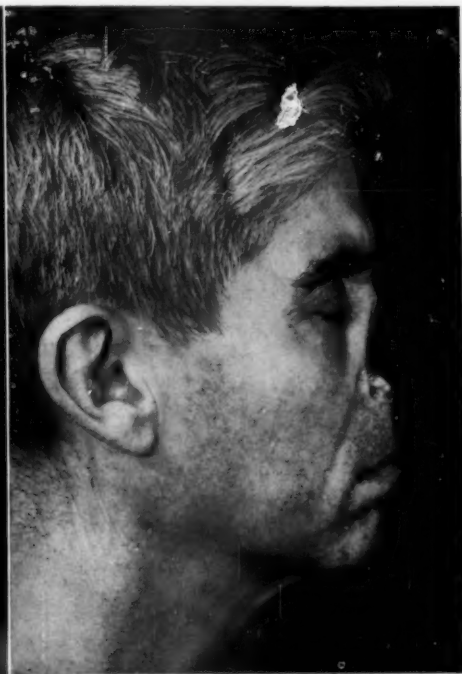
Case 8.—A. P., U. S. Veterans Hospital, No. 95,804. *Recurrent basal cell carcinoma of the nose; complete amputation of the nose; reconstruction by flap from abdomen transferred via the wrist.* This veteran, 60 years old, underwent operation for "tumor" of the skin of the nose in 1940 at another hospital. On admission to this Veterans Hospital in

MALIGNANT TUMORS OF HEAD AND NECK

A



B



C



D



FIG. 5.—(A and B) Total loss of the nose after removal of recurrent basal cell carcinoma. (C) Artist's sketch of appearance as abdominal flap was being migrated to nose via the forearm. (D) Appearance after adjustment of the abdominal flap and revision of the tissues (Case 8).

June of 1947, there was a recurrent tumor which invaded almost all of the soft tissues of the nose and the nasal bones as well. The entire external nose was amputated on June 13, 1947. Skin was sutured to mucous membrane. The patient left the hospital but returned a year later asking for reconstructive surgery. Patterns of the amount of tissue necessary to provide a double-faced flap for nasal reconstruction were applied to the forehead and it was determined that there was not sufficient tissue in that area to allow for construction of the flap. Therefore, a double-faced abdominal flap was created and subsequently trans-



FIG. 5.—(E) Appearance after adjustment of the abdominal flap and revision of the tissues (Case 8).

ferred to the wrist. At a third operation, the flap was detached from the abdomen and sutured into the remnant of nasion. Three operative revisions were required to achieve acceptable appearance. There has been no evidence of disease in the two-year period since radical excision (Fig. 5).

In the discussion of the relative values of surgical excision and radiation for the treatment of cancer of the head and neck, a powerful argument for the former is presented by those experienced in reconstructive surgery. The fibrosis of regional tissues, the aftermath of radiation therapy, precludes the use of flaps of regional tissue. Flaps rotated from areas subjected to scatter radiation often are not viable. Furthermore the depth of fibrosis is such that the characteristic deformity of a portal of entry for radiation is one of dense scar and telangiectasia. Areas of soft tissue so treated do not have sufficient

circulation to support a free skin graft. Case 9 calls attention to this problem. This case represents a dramatic triumph for roentgen ray therapy in that the patient is free from evidence of disease nine years after treatment of carcinoma of the naso-pharynx. The reconstructive surgery in this case was limited to the excision of surface areas scarred by the therapy and reconstruction by tubed pedicles of skin and fat.

Case 9.—J. V., N. Y. H., No. 473,164. *Carcinoma of the naso-pharynx cured by roentgen ray therapy; scarred portals of entry excised and defects corrected by tubed pedicles.* This man, 23 years of age, was referred from Memorial Hospital, New York City, in 1947. Treatment for transitional cell carcinoma, Grade IV, of the naso-pharynx had been carried out by roentgen ray in 1940. In January, 1941, intensive radiation was given, 3000 to 3600 R through each of four ports. This was followed by interstitial radiation. There was no evidence of disease, but the scarred portals of entry over both malar areas and both submandibular areas were the cause of major complaint. The success of radiation therapy in the control of this tumor seemed to justify the removal of damaged skin and subcutaneous tissues and replacement with normal tissue. Reconstruction was done in 1947 by means of two long thoraco-abdominal tubed pedicles. These were detached at their lower ends and transplanted first into the malar areas on either side and then into the submandibular areas. Fairly good color match has been effected by tattooing. The patient has shown no evidence of disease in the nine-year period of follow up (Fig. 6).

The ready sacrifice of the mandible usually is a necessary step in the radical excision of malignant tumors of the floor of the mouth, the gingiva, the cheek, and the mandible itself. The tendency to carry out this procedure as a hemimandibulectomy, disarticulating the temporo-mandibular joint on the affected side, is ill-advised. The upper portion of the ramus, down to a point 2 cm. below the sigmoid notch is necessary for reconstruction of the jaw, since this portion harbors the joint and the attachment of the temporal muscle. Except in the cases of adamantinomata, the tumors for which mandibulectomy is advised seldom invade the upper portions of the ramus. Since this structure is needed for successful reconstruction of the jaw, it seems advisable to preserve it, transecting the mid-portion of the ramus at the time of primary excision of tumor. Failure to provide for immobilization of the undiseased mandible at the time of tumor excision allows for medial displacement of this structure with contracture and shortening of attached musculature, a complication which never can be overcome completely. A plea is made for the consideration of the principles of reconstruction at the time of mandibular resection. Unless these are taken into account, there is a tendency to allow an important interval of time to elapse following extirpation of tumor, an interval of a varying number of weeks during which contractures develop. Such contracture can be prevented on the sound side by intermaxillary wiring of mandibular and maxillary teeth. It can be prevented even on the resected side by the suture of residual pterygoid, masseter, buccinator and geniohyoid muscles around an intramedullary splint. Case 10 is an example in which this method is being used while the patient awaits reconstruction of the mandible by bone graft. Case 11 is one

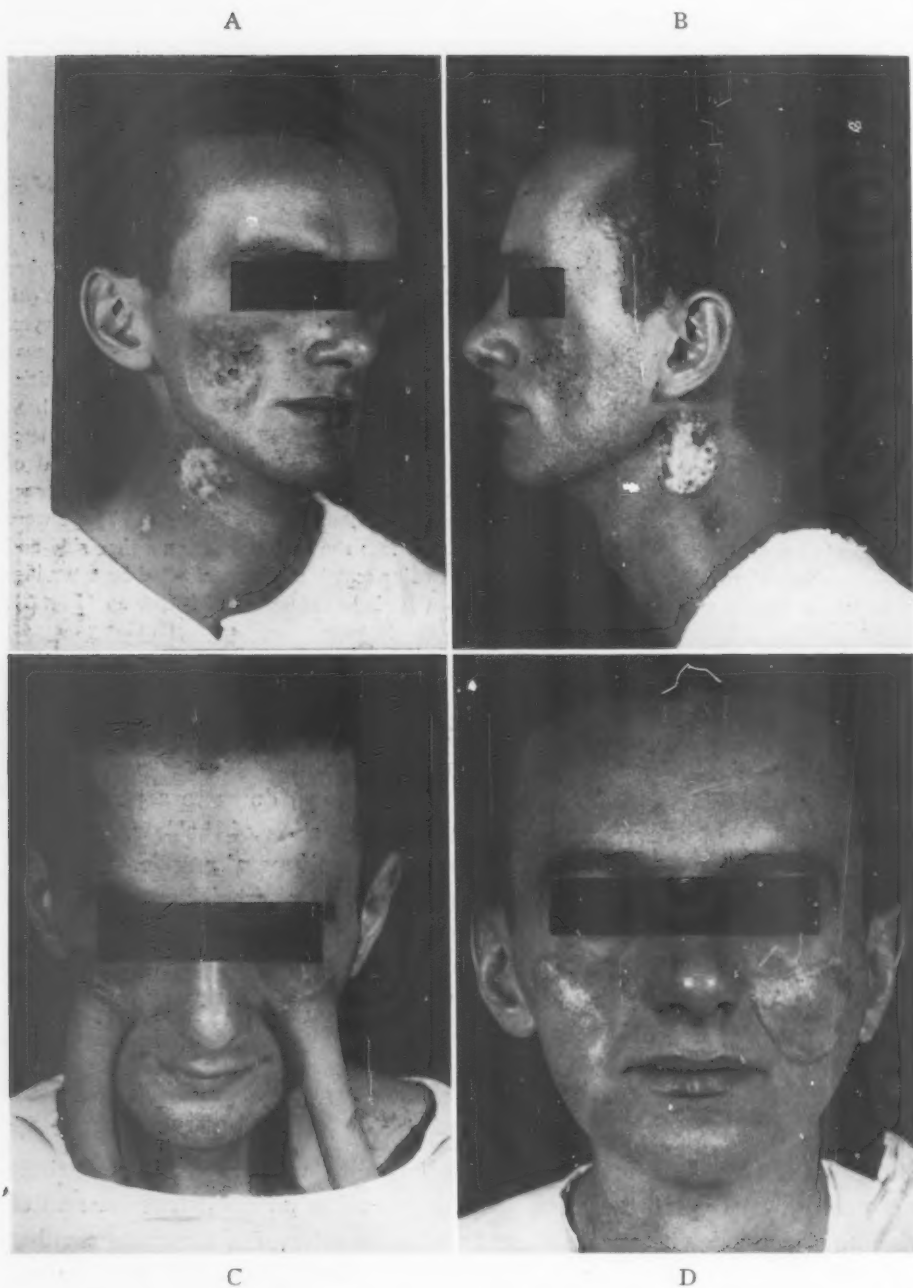


FIG. 6.—(A and B) Post radiation scarring of the malar and cervical areas following intensive treatment for transitional cell carcinoma of the nasopharynx. (C) Thoraco-abdominal tubes affixed to the malar areas after excision of the scars. Subsequently the tubes were detached from the chest and their inferior ends utilized to reconstruct the sub-mandibular areas after excision of the lower scars. (D) Appearance after final revision (Case 9).

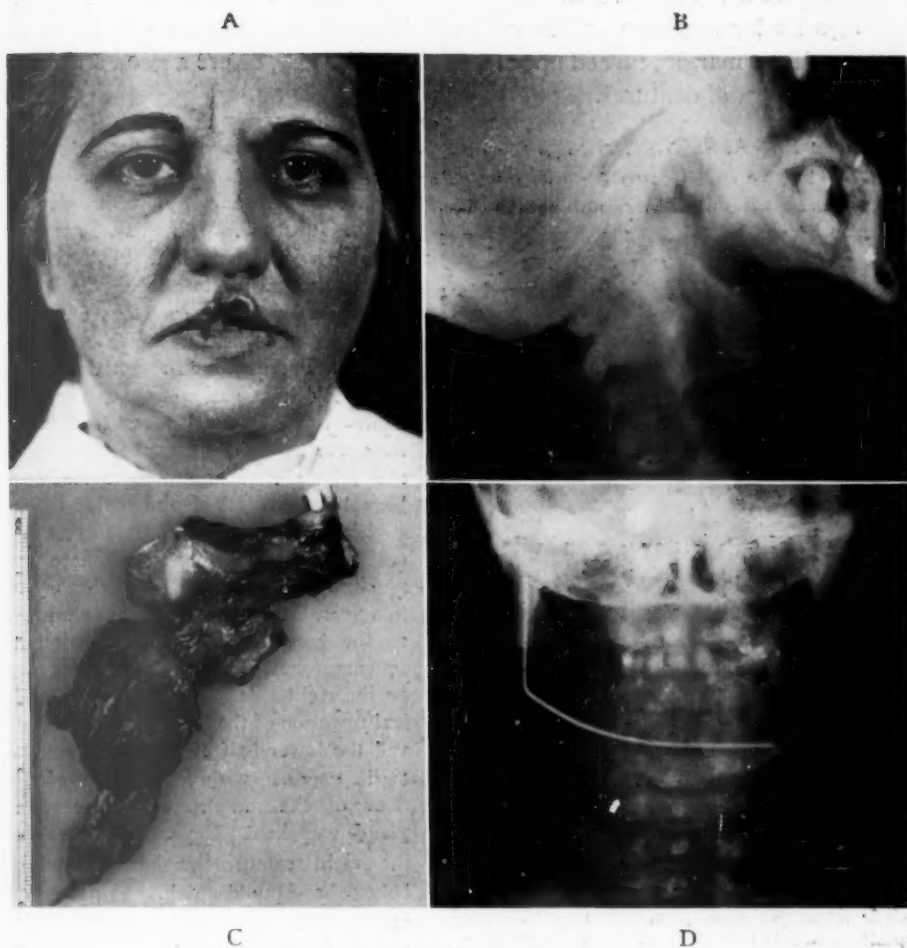


FIG. 7.—(A) Epidermoid carcinoma of the lip of two years duration. Block excision was carried out and the lip was reconstructed by the excision of triangles of soft tissue from either side of the lower lip and the medial advancement of two lateral flaps. (B) Roentgen rays showing erosion of the mandible by squamous cell carcinoma of the gingiva which occurred ten months after treatment of the upper lip lesion. (C) Photograph of specimen which was excised *en bloc*. It consisted of mucous membranes of the cheek and the floor of the mouth, the body of the mandible and the entire sheath of cervical nodes with attached sterno-cleido-mastoid muscle and jugular vein. (D) Photograph of roentgen ray showing the use of a Kirschner wire which was used as an intramedullary splint. Remnants of the muscles of mastication were sutured about this wire. Teeth of the left mandible were then wired to those of the maxilla for immobilization. The method maintains the position of mandibular fragments ideally until such time as permanent reconstruction of the mandible by bone graft is carried out.

in which the function of the sound side was preserved by intermaxillary wiring. The defective side was reconstructed by the use of a free autogenous rib graft, fractured and bent at its mid-point to produce the effect and shape of the angle of the mandible. Though some prefer grafts of cancellous bone from the ilium for mandibular replacement, the rib graft is considered more useful since its sharp inferior margin, turned upward *in situ* in the jaw, offers a good structure for the support of dentures.

Case 10.—A. S., N. Y. H., No. 507,141. *Squamous-cell carcinoma of the upper lip; resection; squamous-cell carcinoma of the gingiva; resection with partial mandibulectomy;*



FIG. 7.—(E) Appearance of the patient while wearing the temporary intra-medullary splint (Case 10).

temporary fixation by intramedullary splint. In April, 1948, this 46-year-old housewife was admitted to the New York Hospital for treatment of a lesion of the upper lip of two years duration. This proved to be a squamous cell carcinoma. There was no regional adenopathy. Block resection was carried out at that time. Primary reconstruction of the upper lip was done at the same operation, by the advancement medially of lateral flaps of labial and malar tissue, excising triangles of soft tissue just lateral to the lip on either side. There was no cervical adenopathy. In February of this year, the patient was again admitted to the hospital with a new lesion, a squamous-cell carcinoma of the gingiva on the right side. On February 4, radical resection of the body of the mandible and the lower half of the ramus on the right, together with the mucosa of the floor of the mouth and the cervical glands was done. The upper one inch of the right ramus, the bony structure below the sigmoid notch, was preserved and the position of the left mandible was maintained by the use of an intramedullary splint fashioned from Kirschner

wire. The pterygoid, masseter, geniohyoid and genioglossus muscles were sutured to each other around the wire splint. Fixation was secured by wiring the teeth of the left mandible to those of the maxilla of the same side. Postoperative convalescence has been uneventful. The patient is now ready for bone graft (Fig. 7).

From the management of Case 10, one may reasonably inquire as to why bridging of mandibular defects is not carried out by means of steel, silver, or vitallium plates at the time of excision of tumor. Because of salivary contamination, such plan is doomed to failure more often than it meets success. The same principle applies to the use of free grafts of bone at the time of primary excision. The intramedullary splint (Kirschner wire) is justified only because its use adds little to the operative trauma and it represents a minimum of for-

MALIGNANT TUMORS OF HEAD AND NECK

eign body. Since full normal motion of the jaw is apt to dislodge the wire, its use is advised only until the mucosa of the oral cavity is healed completely and soft tissue swelling has subsided, at which time it should be replaced by bone graft. The technic of removing the mandibular fragment from the surgical specimen, boiling it to kill tumor cells and replacing it, has been suggested. The author has not used this method but has seen one case in which nonunion has resulted. Obviously, thermal death of tumor cells cannot be accomplished

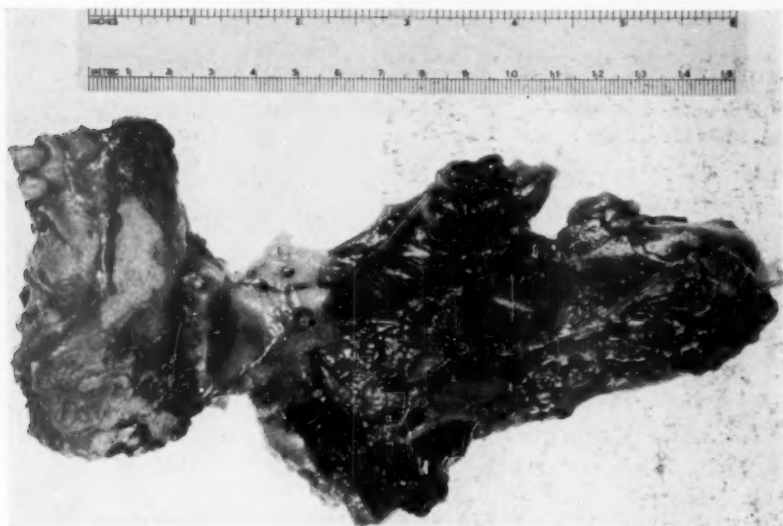


FIG. 8.—(A) Specimen removed in the case of carcinoma of the gingiva invading the mandible. The cervical nodes, sterno-cleido-mastoid muscle, internal jugular vein, body of the mandible and the regional mucous membranes were removed *en bloc* with the lesion (Case 11).

in bone without death of living bone cells. The fragment then is replaced as a sequestrum, subject to the hazard of salivary contamination. However, Ray and Parsons⁵ replaced boiled cranial bone plates immediately in eight cases with good results in six. The method may offer promise in the management of defects of the mandible.

Case 11.—A. P., N. Y. H., No. 49,381. *Epidermoid carcinoma of gingiva; radical resection with partial mandibulectomy; reconstruction by rib graft.* In 1945, this man, who was then 55 years of age, was admitted to the New York Hospital with the complaint of pain in the jaw of 8 weeks duration. Examination showed an ulcerated, fungating mass 3 by 1 cm. over the gingiva in the region of the second and third molar teeth. There was a palpable node just under the angle of the mandible and fixed to it. Roentgen ray showed erosion of the body of the mandible. On December 21, 1945, radical resection of the floor of the mouth, the body and lower half of the ramus of the mandible on the right and the cervical nodes was done by Doctor Andrus. The wound was sutured and the left mandible was fixed to the maxilla by intermaxillary wiring. Microscopic examination showed that the lesion was a well differentiated epidermoid carcinoma with metastases to



FIG. 8.—(B) Roentgenogram showing mandibular defect after excision of the lesion. Note that the upper one inch of the mandibular ramus has been preserved. (C) Roentgenogram after reconstruction of the mandible by means of a free graft from the rib. The graft was fractured so that it could be bent to simulate the angle of the mandible in shape. The point of greenstick fracture was supported by a wire loop. (D and E) Appearance of the patient three years after resection and reconstruction (Case 11).

MALIGNANT TUMORS OF HEAD AND NECK

the cervical nodes. On May 13, 1946, the patient was readmitted to the New York Hospital and the mandible was reconstructed by the use of an autogenous rib transplant. This was wired to the remaining fragment of ramus and to the body of the mandible on the left. The rib graft was bent by greenstick fracture to simulate the shape of a normal mandible. The wound healed per primam and the graft united solidly. Patient showed no evidence of disease 3 years and 3 months after radical resection. He has full function of the lower jaw and chews well, though he has preferred not to be fitted with an artificial denture (Fig. 8).

COMMENTS

In the management of malignant tumors of the head and neck, the problem of rehabilitation of the patient is second in importance only to the cure of the tumor. Unhesitant sacrifice at operation of important regional anatomic structures has been met by the developments in reconstructive surgery. Accordingly, an increasingly higher percentage of these cases are being assigned to therapy by surgery. Argument against radiation therapy is advanced in that regional tissues do not lend themselves to reconstruction after such therapy. A plea is made for further emphasis on reconstruction in the management of patients with malignant lesions of the head and neck. Utilizing the principles of reconstructive surgery, the defects created at operation often may be corrected immediately by rotation flaps or free grafts. In those cases in which further reconstructive steps are required, infection should be avoided by the closure of wounds exposed to salivary contamination, and by the maintenance of normal position of remaining mandibular fragments and of muscles attached to the mandible. Further conservation of time may be effected by carrying out the first stage of reconstruction of soft tissue flaps at the time of extirpation of tumor. A plea is made for extended effort on the part of surgeons to carry the patient with a malignant tumor of the head and neck through to the goal of complete rehabilitation.

BIBLIOGRAPHY

- ¹ Peer, L. A.: Arch. Otolaryng., **38**: 156, 1943.
- ² Brown, J. B., B. Cannon, C. E. Lischer, W. B. Davis, A. Moore and J. Murray: Plastic and Reconstructive Surgery. Surgery, **1**: 124, 1946.
- ³ Dupertuis, S. M.: Plastic and Reconstructive Surgery. Surgery, **1**: 135, 1946.
- ⁴ Conway, Herbert, and John P. Docktor: Surg., Gynec. & Obst., **84**: 866, 1947.
- ⁵ Ray, B. S., and H. Parsons: Replacement of Free Bone Plates in Routine Craniotomies. J. Neurosurg., **4**: 299, 1947.

BURNS FROM ELECTRICITY*

G. KENNETH LEWIS, M.D.†

CHICAGO, ILLINOIS

THE MOUNTING FREQUENCY of serious burns from contact with electric current stems from the constantly extended use of electricity for lighting and power, requiring transmission of electrical energy in conduits of large voltage and amperage, in the form of a continuous or alternating current.

The tension is measured in volts, and if 1,000 or less, is spoken of as low tension current; if over 1,000, as high tension. The intensity of the amperage of the current which will affect the human frame depends upon its voltage and upon the resistance of the human body, which last is always a variable factor. If the body is well insulated and cannot conduct the current, it will not be damaged even by high tension voltage. However, if the body is wet and well-grounded it becomes a good conductor of electricity, and currents as low as 25 volts, are considered dangerous by Jellinek.¹² It is stated by Williams²⁸ that 110 volts are usually fatal if the skin is moist, if a large contact is made, and the current passes through the heart in sufficient quantity to throw the ventricles into fibrillation. The shock received is more dependent upon the conditions of contact than upon the nature of the current with which contact is made. Kennelly¹⁵ has shown that contact with a 1,000 volt high tension current for a brief moment with a dry hand or finger may be less dangerous than 110 volts grasped with a wet hand while the person is standing in the water of a well-grounded bath tub.

Following an accident, only the voltage may be determined, because the resistance of the body at the time of the accident is unknown and the ability of individuals to sustain a shock of electricity differs widely. Critchley³ has shown that it is not a question of build, as some slight individuals bear electric shock well. The elderly, the arteriosclerotic, the alcoholic, the individual with a disturbed thyroid, and those with a greasy skin, are more susceptible. Jellinek¹³ claims an individual with heart disease can withstand as much as one with a normal heart.

Electrical burns may be divided into two types: contact and arc. Contact burns vary from pin-point size to large surface areas; the arc burn is received from an extremely high degree of temperature, measuring 2500 to 3000 degrees centigrade. According to Lewis¹⁷ this temperature is capable of melting and volatilizing bone, and the reaction may vary from a slight blister to deep tissue destruction. Jellinek¹² believes that electrical wounds from electric sparking and contact with high tension current are different from electric heat and chemical burns; their main characteristics are absence of pain, retaining for days or weeks their original appearance, and a remarkable tendency to heal after a period of latency which may be a few days or even weeks. Large

* Submitted for publication January, 1949.

† F.A.C.S., Assistant Clinical Professor of Surgery, University of Illinois Medical School.

portions of the soft tissues in the region of the wound, as well as bone, may separate spontaneously, without causing any noticeable discomfort, irritation, or suppuration.

Besson¹ describes the burns due to high tension accidents as characteristic only by their combination with current markings: they form a homogeneous block, uniformly mortified in all parts; they are located in the intact skin like a seal. In the center, a deep groove extends down to the underlying structures, into the muscles, and at times even into bone; the walls of the groove are irregular, black, and sometimes covered with deep red islands. As in the typical current markings, pain and reactive suppuration are absent; complications are rare. The demarcation of all the necrotic tissue may lead to severe functional disturbances. Jellinek¹³ and Riehl²⁴ describe a rare type of current mark resembling a bullet wound; it is a round hole penetrating skin, musculature and even bone, and is explained as the result of the sudden formation of steam in the tissues, which finds its way out under great pressure.

The lesion produced depends upon the path of the current. It is believed by Jaffe¹⁰ that the current spreads radially from the place of entrance, to be collected again at the point or points of exit, with the greatest density of the electrical field at the points of entry and outlet. Resistance of the skin, which is second only to bone, is varied by moisture, cleanliness, thickness, the part of the body, and the size, shape and firmness of the electrode. The effect of the current upon the skin, as described by Jaffe, is two-fold: in passing through skin the electric energy is transformed into heat, which alters the structures along the way of the current, the result being the so-called current marking, which to a certain extent is specific and of diagnostic value; secondly, free discharge causes the formation of electric sparks, which lead to formation of burns of the third degree. In high tension accidents the burns may entirely obscure the typical markings, which can be seen after injury by lower voltage.

The macroscopic appearance of a typical current mark is as follows:

1. Shape—round, oblong, rosette-like or linear.
2. Diameters—varying from a few millimeters to several centimeters.
3. Area—slightly elevated and pale gray, grayish-white, yellowish-gray or yellow.
4. Hair is unchanged.
5. Surface shows a negative of the electrode.

Accidents occur as the result of ground contact, according to Pearl,²² which is a variable factor. The resistance of dry shoes is high, but is diminished by moisture, so that a current may traverse the body, causing death; also, shoes containing iron nails are particularly dangerous, if the ends have worn through the inner sole.

According to Wildegans²⁷ and Blue,² burns caused by electricity often show a tendency to progress beyond the visible changes noted immediately following an accident.

The apparently healthy tissue surrounding the wound may become necrotic, and at times the entire extremity is involved. The original examination will not determine the extent of the injury. This progressive character of the wound seems to be caused by alterations of the blood vessels, and large sections of them may be involved. Jellinek¹⁴ noted that the walls of the vessels through which the current passes are friable and brittle; the endothelium is changed and parietal thrombi are attached to the intima. The great vulnerability of the vessels accounts for the severe hemorrhages which may complicate injuries due to electricity, and also explains the great difficulty often experienced in ligation of the arteries near the wound. In the examination of the arteries of a lower limb, amputated eight days following a burn from 10,000 volt alternating current, Martin, Couvert and Dechaume¹⁰ observed the elastica interna to be separated from the media, with necrosis of the media and to a lesser degree, of the intima. This necrosis was considered to be secondary to a destruction of the elastica.

As the current traverses the body, tetanic contraction of the entire musculature is produced; the most severe form is designated by Naville and De Morsier²¹ as rigid contraction. Observers of accidents caused by electricity often describe the individual as being in extreme opisthotonos. These contractions may be so strong that muscles are torn (Hackl⁸ and Sandroch²⁵), joints may be luxated (Jaeger⁹), and bones may be fractured (Zimmern²⁰). The individual may be thrown away from the electrode by the muscle contractions, or he may be fixed to the electrode until the current is broken.

Frommolt⁷ describes a fixation of a hand through which a current had entered, into a claw-like position, for hours after an accident, demonstrating the tetanic contractions which sometimes outlast the passage of the current, and describes the muscles in the arm as firm, dry, reddish and friable. According to M. B. Schmidt²⁶ the microscopic picture is interesting; there is a displacement of the contractile substance. Instead of the fine cross striation, coarse, hyaline transverse bands are seen; the fibrils pass through these bands which are composed of the compressed anisotropic disks of the muscle fibers. These are the sites of the most extreme and irreversible contractions.

Bone lesions are common, notwithstanding that bone has the greatest resistance of all tissues to the electric current. Finton⁵ states that a large surface like the skull, with its diploe and blood vessels, offers less resistance than a thin layer of soft tissue which covers it, and the current will, therefore, pass through the bone. The bone is often exposed by the destruction of the soft tissues, and the area is dry and yellowish-white, usually demarcating in four to five months. It is the opinion of Mason and Lester²⁰ that the necrosis of bone is due to loss of periosteum. Quenu²³ maintains that bone may live without periosteum, and considers the necrosis a direct result of the electric current. The sequestration may involve particular parts of the entire bone. It is impossible to determine the extent of the alteration of a bone immediately after an accident; therefore, conservative therapy is recommended.

BURNS FROM ELECTRICITY

It is stated by Jaffe, Willis, and Backem,¹⁰ that full consciousness is maintained by some people in an electrical accident; they scream for help and are even able to free themselves. Others lose consciousness without a sound, and

FIG. 1



FIG. 2



FIG. 3

FIG. 1.—The progressive loss of tissue in the wrist, which on initial examination appeared as a third degree burn, resulting in loss of all flexor tendons and nerves at wrist.

FIG. 2.—The blood vessels in this wound are friable and brittle, and in surgical procedure it will be found extremely difficult to ligate the vessels, as the forceps will break off the vessel.

FIG. 3.—Gangrene developing in these hands 11 days following contact with high tension current.

some go into coma immediately the circuit is broken. In legal executions, MacDonald¹⁸ writes that abolition of consciousness is instantaneous. The morbid changes described by Critchley,³ consist of severe cerebral edema, with associated high intracranial tension, and the principal lesions found are: petechial hemorrhages throughout the central nervous system, most marked in the region of the fourth ventricle and medulla; chromatolysis of the neurones throughout the central nervous system, and in the peripheral nerves, fragmentation and twisting of the axons; breaking down of the sheath of Schwann with fusion of its constituent nuclei; and endothelial infiltration of the epineurium. He also describes an electric shock as similar to a blow causing cerebral concussion, with the usual symptoms of headache, vertigo, nervousness, insomnia, defective memory, psychoneurotic syndromes, et cetera, and states of mental aberration, with delirium and hallucinations developing some months after an accident.

There is considerable variance of opinion as to whether death is due to cardiac damage or respiratory paralysis from action on the medulla. Koeppen¹⁹ has been able to show from animal experiments that cardiac damage is the principle cause of death, and also explains why artificial respiration will maintain sufficient circulation to keep the cellular elements of the central nervous system alive.

Immediately following shock respirations may cease while the cardiac action continues, but this is explained by tonic spasm of the respiratory muscles, and breathing is resumed as soon as electrical contact ceases. Respiration has been observed after the heart has gone into fibrillation or has stopped.

REPORT OF CASES

Case 1.—N. S., a white male, age 19, was riding in a half-track military vehicle when the radio aerial came in contact with a high tension, 11,000 volt transmission line, in a bivouac area. He grabbed the body of the truck and froze to the metal of the conveyance; consciousness was lost before the current was broken.

He received third degree burns of the scalp and external deploe of the skull from the arcing of the current. The right hand received third degree burns of the palm and second, third and fourth digits, with fixation of the tendons and burns of the bones of the palm and the right shoulder on the posterior aspect. Both feet were burned: on the right, the second, fourth, and fifth toes; on the left foot, the first toe.

Conservative care was given until areas were covered with red, healthy granulations. Thick split grafts were applied to the granulating areas of scalp, shoulder, hand, and feet. The initial attempt at scalp repair was a failure, in spite of the presence of apparently healthy granulations. Ultimately, however, the scalp sloughed some of the external layer of the bone of the skull, and then was healed by a free graft. The second carpal bone of the right hand sloughed at the end of the ninety-sixth day. The fingers remained fixed for ten days, resisting all attempts at mobilization. Attempts at skin grafting the feet resulted in failure, but they finally healed by the one hundred and forty-second day.

This case demonstrates the findings of Frommolt,⁷ in which the hand becomes fixed in partial flexion for a period of ten days following the accident, defying all attempts at movement, either active or passive. The skull burn demonstrates the destruction of the bone so ably described by Finton;⁵ however, the demarcation was not complete in

BURNS FROM ELECTRICITY

one sequestrum. The reparative attempts at cover for the feet clearly demonstrate the healthy appearance of the wounds and lack of healing that can be expected, until the period of latency has expired, and repair is possible.

Following the accident, this patient had many complaints. These were for the most part ungrounded, and personality change was from that of a very well-oriented soldier to one very quarrelsome and mischievous, with hallucinations of imaginary abuses from other patients.

FIG. 4



FIG. 5



FIG. 6



FIG. 7

FIG. 4.—Showing exposure of the diploe of skull from arc of electricity, with 11,000 volts of high tension current.

FIG. 5.—Flexion and fixation of the wrist and elbow with loss of skin of forearm exposing the ulna showing the loss of periosteum.

FIG. 6.—This shows the bone exposed with surrounding tissues healed and partial relaxation of wrist from initial fixation with the forearm still flexed on the arm.

FIG. 7.—The effect of low tension current with loss of index finger and part of thumb developing gangrene immediately, with charring.

Case 2.—P. I., a male age 23 years, was injured while working on a telephone line, April 22, 1945, in Germany; a wire containing 7200 volts of alternating current was picked up. The patient was standing on dry ground, early in the morning, with the chill of spring still in the air. The current was broken by his alert fellow worker cutting the wire with an axe, and the period of time was estimated as approximately 10 seconds. He was frozen to the wire without losing consciousness.

The patient was first seen at a general hospital April 26, 1945, at which time his hands were burned as follows: burns of flexor surfaces of all eight fingers, varying in depth and distribution, with sensation and circulation present; both wrists on flexor surfaces burned to a third degree, the integument of the right wrist burned all the way around. Other injuries were not demonstrable. He was cared for conservatively until April 29, 1945, when a profuse hemorrhage developed from the right radial artery. Control of the hemorrhage at the wrist was impossible. The artery was located in the mid third of the forearm, and attempts at ligation were without success. When a forcep was applied, the vessel broke off, requiring higher ligation, which was successful only at the level of the junction of upper and middle third of the forearm. Blood transfusions were necessary following this hemorrhage.

Circulation was watched closely in this hand, and appeared to be good.

On examination of the hands on May 3, 1945, gangrene was discovered in both hands, with definite areas of demarcation involving both hands at approximately the same levels. Amputation was performed, removing both hands at point of election; recovery was then uneventful.

This case demonstrates the dangers and difficulties encountered in control of hemorrhage in electrical injuries, and the friability of the blood vessels.

Case 3.—E. J., a white male age 26, was injured while working as a radio engineer. During the repair of a radio the current was built up to 750 volts, resulting in charring of the index finger of the left hand, third degree burns of the other 3 fingers and forearm, and gangrene of the thumb. There was a third degree burn of the right chest, and first and second degree burns of the right hand. The patient was cared for conservatively until demarcation of soft tissues.

This patient received burns from a low tension current while standing on concrete. The loss of integument was replaced without difficulty, with full return of function of all joints, except the terminal joint of the third finger on the left hand.

This case may be contrasted with Case 2, in which the patient received a high tension shock with loss of blood supply and gangrene, distant to the contact set in.

Case 4.—J. P., a white male age 32 years, a lineman, came in contact with 6600 volts alternating current while stringing a new high line. The patient was making a splice and inadvertently became partially grounded, receiving severe burns of both hands and forearms. The right hand received burns severe enough to produce gangrene of the index finger and destruction of all flexor tendons of the wrist, together with the integument; the left hand suffered destruction of the skin from the metatarsal phalangeal joints, upward to midforearm, and destruction of the tendons of both flexor and extensor surfaces, plus bony necrosis of metacarpal and carpal bones.

On August 23, 1948, hemorrhage occurred in the left wrist, which was controlled only by ligating the radial artery just below the elbow. Sensation of both hands was zero to the region above the wrists.

On September 5, 1948, both wrists were placed in abdominal and chest flaps for cover and subcutaneous tissue base, after the necrotic metacarpals were removed.

On October 28, 1948, the pedicles of flaps were sectioned and fitted into place, and attempts at tendon and nerve graftings were contemplated for a later date.

Case 5.—T. A., white, age 28 years, occupation electrician, did not remember how his accident occurred on June 22, 1948. On questioning, his remark was, "I got tangled

BURNS FROM ELECTRICITY

up in some high voltage electricity, is all I remember." His fellow workmen gave the following account: At quitting time the tools were being gathered and the patient reached down to pick up a wire on the ground; they heard him scream, and he was thrown approximately ten feet away from the wire by the shock. Consciousness returned after a period of what was estimated to be ten minutes, and during this period artificial respiration was administered. He was then placed in a truck and transported about 15 miles to a hospital.

FIG. 8



FIG. 9



FIG. 10



FIG. 11

FIGS. 8 and 9.—The resultant deformity of hand, repaired with a skin flap from thigh and physiotherapy.

FIG. 10.—Destruction of both hand and soft tissues with devitalized bone and tendons in situ.

FIG. 11.—Replacement of lost soft tissues, and protection of tissues remaining by use of abdominal and chest flaps.

Physical examination on arrival at the hospital revealed burns of both hands and arms of undetermined degree, and the back between the scapulae. The left arm was flexed at the elbow and the hand flexed on the wrist. The right hand was flexed on the wrist with burns of the forearm and wrists, of undetermined degree. In both axillae were openings in the skin similar to bullet wounds, as described by Jellinek¹³ and Riehl.²⁴ The patient was cared for conservatively from June 22, 1948, to August 4,

1948, during which time the left arm remained flexed at the elbow and the hand flexed on the wrist.

On August 4, 1948, the following injuries were present: a granulating area between scapulae, circular in outline, depressed from the surface and about 8 inches in diameter; in both axillae round penetrating wounds with exuberant granulations and white, thin pus extruding from these two wounds which were approximately one centimeter in diameter; the left arm had an opening in the bend of the elbow, filled with whitish-gray

FIG. 12



FIG. 13



FIG. 14

FIGS. 12 and 13.—Resultant flaps in place providing cover and subcutaneous tissue for protection and definitive care.

FIG. 14.—Flap on the right and free graft on the left, with bare bone left exposed.

BURNS FROM ELECTRICITY

necrotic tissue extending upward under the integument approximately 3 inches, and down into the muscles of the forearm. The integument of the lateral surface of the forearm had been replaced by red, friable granulations, and two areas of the ulna in mid-forearm exposed; the dorsal surface of the hand was covered with granulations; at the right forearm, extending from the crease of the wrist upward to the middle of forearm on the flexor surface, was an area extending from side to side and filled with necrotic tendons, nerves and exposed bone.

On August 12, 1948, an abdominal flap was applied to the right wrist for cover, preparatory to a tendon transplant, and a free graft placed over the granulating surface of the left forearm.

On September 9, the pedicle of flap was released, and during this time the control of the left hand returned, although the patient still had a partial flexion of the wrist, and about 50 per cent of the normal power to the muscles. The elbow had about 45 degrees of motion on the left and 160 degrees on the right. The bone at this time had not separated, and with the flap on the right and free graft on the left, the bare bone was left exposed. The patient used the left hand very clumsily, with only partial control.

TREATMENT

The first rule is to disengage the victim from the current, either by turning off the power or by short circuiting. Secondary accidents will happen if the rescuer does not protect himself by insulation or by using a non-conducting object as a stick of wood or piece of rubber, in trying to knock the wire or electrode from the grasp. The medical emergency treatment consists of cardiac massage, if applied within five minutes. Artificial respiration is necessary, and may be required over a considerable period of time. Cardiac stimulants are recommended, but if fibrillation occurs the heart rarely recovers.

Conservative care is imperative, because on initial examination it is impossible to determine the extent of the injury. The damage to tissue is progressive, so that a prognosis should be delayed for several days or weeks. A relatively simple appearing injury may ultimately result in a catastrophic loss to the individual, as demonstrated by Case 2.

The definitive care will be dependent upon the tissue destruction, and the tissue replacement will many times present a difficult challenge to the physician's skill and ability to obtain healing and return of function. This is demonstrated in Case 1, which resulted in failure of all attempts at grafting, and Cases 4, and 5, where tendons, nerves, muscles, and bony tissue were lost.

SUMMARY

The frequency of serious accidents from contact with electric current poses a difficult problem, both from the standpoint of severe burns with extensive tissue destruction, and extreme shock, which often results in change of personality and many times in death.

Prompt emergency treatment is, of course, imperative for the restoration of heart action in cases of extreme electric shock. Since the extent of injury from burns cannot be determined on initial examination immediately following the accident, the import of conservative care is emphasized in the first stages of treatment.

The symptoms and findings may be immediate, secondary, or delayed, and because the damage to tissue is progressive in this type of burn, prognosis should be delayed.

Two types of burns are distinguishable: that from contact and that due to arc. Lesions produced by these burns are dependent upon the path of the current, and some writers express the belief that the current spreads radially from the site of entrance and is collected again at point or points of exit, with the greatest density of the electrical field at these sites. Further, it is the consensus of opinion that in passing through the skin, the electric energy is transformed into heat, which alters the structures in the path of the current. This results in a so-called current marking of diagnostic value.

It has been pointed out in the literature that contact with 110 volts is usually fatal if the skin is moist, and the current passes through the heart in sufficient quantity to throw the ventricles into fibrillation. There is, however, a wide divergence of opinion as to whether death resulting from electric shock is caused by cardiac damage or respiratory paralysis from action on the medulla.

Five selected cases have been presented with figures, which graphically demonstrate that ultimate success or failure of repair and restoration of function following burns from electricity, is dependent upon the degree of tissue destruction.

BIBLIOGRAPHY

- ¹ Besson, M.: Les brulures par l'electricite. Arch. internat. de med. lig., Brux., 1: 284, 1910.
- ² Blue, G. E.: Electrical Burns. Internat. J. M. and S., 39: 116, 1926.
- ³ Critchley, M.: Injuries from Electricity and Lightning. Brit. M. J., 2: 1217, 1935.
- ⁴ Critchley, M.: Neurological Effects of Lightning and of Electricity. Lancet, 1: 68, 1934.
- ⁵ Finton, W. L.: Electrical Injuries. J. Michigan M. Soc., 29: 775, 1930.
- ⁶ Fisher, H. E.: Electrical Burns. Internat. J. M. and Surg., 49: 9, 1934.
- ⁷ Frommolt, G.: Zwei Falle von Tod durch elektrischen Starkstrom. Monatschr. f. Unfallheilk., 27: 169, 1920.
- ⁸ Hackl: Verletzungen und Tod durch industrielle elektrische Strome. Inaug. Diss. Munchen. 1900.
- ⁹ Jaeger, H.: Ueber startstromverletzungen. Schweiz. med. Wchnschr., 2: 1251, 1921.
- ¹⁰ Jaffe, R. H., D. Willis, and A. Backem: The Effect of Electric Currents on the Arteries: Histologic Study. Arch. Path., 5: 837, 1928.
- ¹¹ Jaffe, R. H.: Electropathology. Arch. Path., 5: 837, 1928.
- ¹² Jellinek, S.: Der elektrische Unfall. Wien. F. Deutike. 1927.
- ¹³ Jellinek, S.: Changes in Electrically Injured Bones. Brit. J. Radiol., 31: 23, 1926.
- ¹⁴ Jellinek, S.: La more par L'electricite, resultats pratiques acquis par l'etude electropathologique. Compt. rend. Soc. de biol., 181: 945, 1925.
- ¹⁵ Kennelly, A. E.: The Danger of Electric Shock from the Engineering Standpoint. Am. J. Electrother and Radiol., 45: 1, 1927.
- ¹⁶ Koeppen, S.: Cause of Death in Accidents Caused by Electricity. Munchener Medizinische Wochenschrift., 80: 1805, 1933.
- ¹⁷ Lewis, D.: Electric Burns Causing Necrosis of the Skull. Am. Surg., 58: 149, 1918.
- ¹⁸ MacDonald, C. F.: The Execution of Czologosz. Philadelphia M. J., 8: 777, 1910.

BURNS FROM ELECTRICITY

- 19 Martin, J. F., P. Couvert and J. Dechaume: Les lésions vasculaires causées par les courants électriques industriels; la désintégration mésoartérielle. *Lyon Chir.*, **21**: 13, 1924.
- 20 Mason, J. M., and B. S. Lester: A Study of Burns Involving the Periosteum of the Vault of the Skull. *Ann. Surg.*, **50**: 815, 1909.
- 21 Naville, F., and G. De Morsier: Les accidents dus à l'électricité industrielle. *Ann. de med. leg.*, **7**: 245, 1927.
- 22 Pearl, F. L.: Electric Shock. *Arch. Surg.*, **27**: 227, 1933.
- 23 Quenu, E.: Brûlures du crâne et nécroses des os du Crâne par électrocution. *Rev. de Chir.*, **43**: 70, 1911.
- 24 Riehl, G.: Die Spuren des elektrischen Starkstromes in der Haut. *München med. Wchnschr.*, **70**: 1119, 1923.
- 25 Sandroch, W.: Ein Fall von elektrischer Starkstromverletzung mit tödlichem Ausgang. *München. med. Wchnschr.*, **59**: 2618, 1912.
- 26 Schmidt, M. B.: Ueber Starkstromverletzungen, *Verhandl. d. deutsch. path. Gesellsch.*, **14**: 218, 1912.
- 27 Wildegans: Verletzungen durch elektrischen Starkstrom mit tödlichem Ausgang. *Klin. Wchnschr.*, **2**: 588, 1923.
- 28 Williams, H. B.: The Problem of Electric Shock. *A. J. Surg.*, **27**, 151.
- 29 Zimmern, M. A.: Les accidents de l'électricité industrielle et domestique: Un nouvel accident de l'électricité domestique. *Bull. Acad. de med.*, **93**: 310, 1925.

LIGATION OF THE SPLENIC ARTERY, THE OPERATION OF CHOICE IN SELECTED CASES OF PORTAL HYPERTENSION AND BANTI'S SYNDROME*

ALEXANDER W. BLAIN, M.D. AND ALEXANDER BLAIN, III, M.D.

DETROIT, MICHIGAN

FROM THE DEPARTMENT OF SURGERY, ALEXANDER BLAIN HOSPITAL AND CLINIC

A TREMENDOUS AMOUNT of progress has been made in both the operative attack on portal hypertension and in the excision of large adherent spleens since the senior author reported the first ligation of the splenic artery for Banti's syndrome in 1918.¹ Whipple,² Blakemore³ and Blalock⁴ have developed the technic of portal-caval anastomosis to the point where this is the operation of choice in most cases of portal hypertension. The technical problems involved in doing a splenectomy for the large adherent spleens seen in Banti's syndrome have been greatly reduced by improvements in anesthesia, pre- and postoperative care with blood replacement, early ambulation and newer suture materials. One of the greatest advances in surgery of the spleen has been the employment of the combined thoraco-abdominal approach popularized by Carter.⁵

Ligation of the splenic artery, while admittedly a less radical and less effective procedure than shunting operations, remains, in our opinion, the operation of choice in selected poor risk patients with portal hypertension and congestive or primary splenomegaly, and we offer it as a procedure of considerable merit in appropriate circumstances. Everson and Cole⁶ have recently brought this operation to the attention of the surgical profession by reporting good results in two of three poor risk patients with portal hypertension. It was their opinion that these patients would not have tolerated more extensive operative procedures. Recently in a progress report of the patient operated upon for Banti's syndrome 34 years ago,⁷ it was mentioned that the operation had recently been performed in other patients. Sufficient time has now elapsed to evaluate the results in three patients operated upon in 1947. The fifth case in this series was operated upon January, 1949. Further time will be necessary to secure the final results in this series.

Prior to reporting the cases mentioned, the effect of ligation of the splenic artery in animal experiments and the technic of operation in patients will be discussed. The results obtained in the first patient with Banti's syndrome operated upon in 1913 will be reviewed.

LIGATION OF SPLENIC ARTERY IN DOGS

Experiments carried out a number of years ago¹ may be summarized thus: When the splenic artery is ligated in dogs, there is an immediate shrinkage

* Submitted for publication December, 1948.

LIGATION OF THE SPLENIC ARTERY

of the spleen pulp. If the splenic vein is ligated with the artery left patent, there is a swelling of the spleen to nearly twice its size and weight. Ligation of either the splenic artery or the splenic vein in the dog, under sterile conditions, can be done without mortality. At a second operation in the experimental animals mentioned above (arterial ligation) the spleen was found to be atrophied and wrapped in omentum. There was no necrosis.

TECHNIC OF SPLENIC ARTERY LIGATION

The technic of splenic artery ligation is usually fairly simple. The vessel can be isolated by opening into the lesser peritoneal cavity through an incision made in the gastro-colic omentum. The vessel, as it runs along the superior border of the pancreas is well visualized as are the tail of the pancreas and the splenic hilus. The vessel is easily palpated and can be isolated from the vein without tearing the vein. Care must be used not to injure the pancreas. The artery is then severed between silk ligatures (two on both proximal and distal stumps). We usually ligate the vessel above the pancreas if it is not too deeply imbedded in the pancreas. Alternative sites have been at a point just distal to the tail of the pancreas and at a point just distal to the origin of the splenic artery, from the celiac artery. To ligate the artery at this last site, the stomach is reflected upward after detaching the gastro-colic omentum. In only one patient in our experience, to be mentioned later, did all three sites prove so inaccessible that splenectomy was the only alternative. The gastro-colic omentum is closed with interrupted silk sutures and the abdomen closed. We now prefer the use of a left upper quadrant transverse incision and the use of steel wire sutures to close the abdomen.

REPORT OF CASES

Case 1.—On March 15, 1913, a 38-year-old Greek laborer was seen because of pain in the left upper quadrant and a mass in this region. He had been short of breath, weak, and unable to work for the preceding two months. The tumor in the left upper quadrant had been present, to the patient's knowledge, since 1894. It had been growing progressively larger.

Physical examination revealed a large tumor filling the whole left upper quadrant and extending about 3 inches below the umbilicus. The splenic notch could be felt very plainly and left little doubt as to the organ involved. The liver was slightly enlarged. The blood examination showed: erythrocytes, 3,840,000; leukocytes, 5,555; polymorphonuclears, 58; large lymphocytes, 5; small lymphocytes, 35.5 and eosinophiles, 1.5. The hemoglobin was 70 per cent. No plasmodia were found. A diagnosis of Banti's syndrome was made and splenectomy was decided upon.

On March 25, 1913, under ether anesthesia, a 13 cm. long left rectus incision was made. There was a moderate amount of free peritoneal fluid. The liver was found to be slightly enlarged. The spleen was enormous and was free on its anterior surface. However, it was firmly bound, posteriorly and superiorly, to the diaphragm by very vascular adhesions. The veins from the spleen were markedly dilated and extremely thin. After attempting to divide some of the vascular adhesions, splenectomy was considered too hazardous and a decision was made to ligate the splenic artery. The artery was isolated about 3 cm. from the spleen, clamped, and tied with chromic catgut in two places. There

was an immediate shrinking of the spleen to about one-fourth its former size. The wound was closed without drainage.

Except for a fever on the first 2 postoperative days, the patient made an uneventful recovery and was discharged on the seventeenth postoperative day. On April 20, 1913, the patient's hemoglobin had risen to 90 per cent. A painful bulge was present in the center of the wound which, when opened with a hemostat, exuded a large amount of broken down splenic tissue. He promptly returned to work.

Over the years the senior author has kept in touch with the patient reported in 1918. The man returned to Greece and settled in Athens. In February, 1947, a letter was received from a mutual friend who stated that he had visited the patient and found him in good health. Thus, 34 years after ligation of his splenic artery for splenomegaly, he was well and had not developed ascites.

Case 2.—(A. B. H. No. H-1607) A 54-year-old white female was seen at the Clinic on April 25, 1947, complaining of anorexia, fatigue, constipation, and weight loss of 35 lbs. during the previous 4 months. For the past month she had been jaundiced. Examination revealed a jaundiced white woman of the stated age with a large palpable mass in the left upper quadrant and evidence of arteriosclerotic heart disease with slight edema of the ankles. There was no ascites or prominence of superficial abdominal veins. The liver was not palpable. Roentgen ray studies showed a small hiatal hernia at the cardia of the stomach, normal small intestine and colon and a non-functioning gallbladder. She was markedly anemic, her hemoglobin being 33 per cent, (1,610,000 RBC). Careful blood studies failed to reveal the presence of spherocytes. The icterus index was 62.8 and no urobilinogen was found in the urine. By means of multiple blood transfusions, she was prepared for operation, and on May 28, a laparotomy was performed.

At operation, the spleen was found to be three times the normal size and the liver appeared to be normal and free of any gross evidence of cirrhosis. No biopsy was taken. The gallbladder was bound by multiple adhesions and contained stones. No stones were palpated in the cystic or common ducts. Because of the condition of the patient and the numerous adhesions about the enlarged spleen, splenic artery ligation was carried out in preference to splenectomy. The artery was approached through the lesser sac via an incision in the gastro-colic omentum. It was freed from the superior border of the pancreas, isolated, ligated with silk sutures and severed. The gallbladder was not removed in spite of the presence of stones because the patient's condition was not deemed sufficiently satisfactory for further operative procedure.

Following the operation, she made an uneventful recovery and remained free of all her preoperative symptoms for 12 months. There was no evidence clinically of necrosis of the spleen. The spleen became no longer palpable presumably due to atrophy. In May of 1948, episodes of jaundice began to recur. Further operative intervention has been advised.

Case 3.—(A. B. H. No. G-3455) A 49-year-old Greek male was first seen at the Clinic on September 30, 1946, complaining of gradual enlargement of the abdomen, swelling of both legs and weakness, weight loss, nausea and vomiting of 6 months duration. He had imbibed large quantities of alcohol for many years. A diagnosis of cirrhosis of the liver was made and several paracenteses were performed prior to ligation of the splenic artery on May 28, 1947. The spleen was greatly enlarged. His postoperative course was uneventful and when last seen in June, 1949 (over 2 years postoperative) he was healthy, working daily and drinking a pint of wine daily. There has never been any hematemesis either before or after operation.

Case 4.—(A. B. H. No. G-2318) A 50-year-old male was first examined at the Clinic on May 27, 1946. He complained of swelling of the abdomen and legs, indigestion and chest pains of a year's duration. The diagnosis of cirrhosis of the liver was confirmed

LIGATION OF THE SPLENIC ARTERY

by peritoneoscopy June 7, 1946. At operation, the spleen was about four times its normal size. Numerous paracenteses were performed prior to transfer to the surgical department and ligation of the splenic artery on June 3, 1947. The patient's postoperative course was not remarkable and he did well until his ascites began to re-accumulate about 7 weeks postoperatively. He refused further paracenteses. On September 8 (four months after operation), he choked while eating breakfast and was in coma when seen a few hours later. He was slightly jaundiced. He expired the following day.

Case 5.—(A. B. H. No. 48-3784) A 51-year-old male from Armada, Michigan, referred by Dr. John R. Boland, January 10, 1949, because of an episode of massive hematemesis 6 weeks previously which had required 4 blood transfusions. He had had no other gastro-intestinal symptoms, but stated that he had noted edema of the ankles during the last 2 months. He had been drinking alcoholic beverages heavily for the past 6 years. He had ascites with shifting dullness and a fluid wave. The liver was enlarged, its border being palpable 5 fingerbreadths below the right costal margin. There was also splenomegaly and the splenic border was palpable 5 fingerbreadths below the left costal margin. There was cheilosis and slight gynecomastia. Roentgen ray studies revealed the presence of esophageal varices, moderate gastritis with probable ulcer deformity of the duodenal bulb and the presence of gallstones.

His hemoglobin on admission was 10 Gm. per 100 ml. blood. There were 7,100 white cells of which 76 per cent were polymorphonuclear leukocytes and 22 per cent lymphocytes. Urinalysis revealed no abnormalities. The icteric index was 9.2 units. A bromsulphalein test showed 30 per cent retention of dye in 15 minutes and 10 per cent retention of dye in 45 minutes. Total serum protein was 6.0 Gm. per 100 cc.; albumin, 3.7 Gm. per 100 cc.; and globulin, 2.3 Gm. per 100 cc. Prothrombin time was measured as 32 per cent of normal. The cephalin flocculation test showed a trace of flocculation in 48 hours.

A diagnosis of Laennec's cirrhosis with portal hypertension and Banti's syndrome was made. Because of the ascites and the episode of massive hematemesis, operation was carried out on January 18, 1949 (A. B. III).

Through a left upper quadrant transverse incision, the abdomen was opened revealing a tremendously enlarged liver and spleen. The omentum was plastered to the diaphragm and over the liver and spleen ("a natural omentopexy"). This omentum contained numerous large dilated veins. The spleen was fixed to the diaphragm and lateral parietal wall by means of numerous very vascular adhesions. It was possible by careful dissection to approach the pancreas through the gastro-colic omentum. After good exposure of the pancreas was obtained, the splenic artery could be palpated running along its superior border. This artery was very tortuous and a thrill could be palpated all along its course and distal to the tail of the pancreas. The splenic vein was also palpable. An incision was made in the peritoneum over the point on the superior border of the pancreas where the splenic artery pulsations could be best palpated. This incision was carried through about 1 cm. of pancreatic parenchyma, exposing the splenic artery which was doubly ligated with heavy silk ties. This large vessel was not severed. The opening in the gastro-colic omentum was closed and then the abdominal incision was closed using wire sutures throughout, and the patient returned to his room in good postoperative condition.

He made an uneventful recovery and was discharged home on the tenth postoperative day. Some 10 months later, in spite of his refusal to discontinue drinking, there has been no further episode of hematemesis and no recurrence of his ascites or edema of the ankles.

DISCUSSION

It is believed that the splenic vein contributes about 40 per cent of the blood entering the portal vein. When the spleen is enlarged, this percentage is

increased. The other 60 per cent comes from the superior mesenteric vein. By ligating the splenic artery, this 40 per cent or more of portal blood flow should be eliminated and a consequent reduction in portal hypertension expected. Indeed, this operation should reduce portal hypertension more than splenectomy because the veins carrying blood for the portal system around the portal bed block via the spleen and its vascular attachments are left intact, whereas in splenectomy they are removed.

Inasmuch as splenectomy in the presence of portal hypertension is an operation of some magnitude, and inasmuch as splenic artery ligation produces a functional splenectomy without always destroying venous anastomotic channels, the advantages of the latter procedure can readily be appreciated. Furthermore, Blakemore has stressed that splenectomy should not be done unless the operator is prepared at operation to do a spleno-renal anastomosis. Once splenectomy has been done, the difficulties in performing a subsequent shunting operation are often almost insurmountable. Previous splenic artery ligation would probably not make a shunting operation as difficult to do if the patient's improvement would allow such an operation at a later date.

In various splenopathies, other than that due to portal hypertension, there are a group of cases in which splenic artery ligation would seem to be the operation of choice. In Banti's syndrome (unassociated with cirrhosis of the liver) where a tremendously enlarged spleen is firmly adherent to adjacent viscera with markedly vascular and friable adhesions, and where the patient's condition is precarious enough to preclude an operation of the magnitude of splenectomy, ligation of the splenic artery is obviously safer than splenectomy. One of us (A. B. III) has had the opportunity to study with Coller⁸ the results of over a hundred consecutive elective splenectomies at the University of Michigan Hospital. As would be expected, in this study, the results in the patients with Banti's syndrome are the most disappointing.

At times in other diseases such as congenital or acquired hemolytic anemia, idiopathic thrombocytopenic purpura,¹² Gaucher's disease, malaria, the Cruveilhier-Baumgarten syndrome,⁹ and so on, one can easily imagine circumstances which would warrant selection of splenic artery ligation over splenectomy. However, in most instances, in a disease such as idiopathic thrombocytopenic purpura in which the possible presence of accessory spleens might be an important factor in the patient's recovery, splenic artery ligation is apt not to be effective treatment.

There is a further important, although rare, disadvantage to a too widespread preference for splenic artery ligation over splenectomy in cases of splenomegaly where the latter operation can be done with relative safety. Rarely an enlarged spleen is due to a primary splenic neoplasm and this lesion might go unrecognized if only the splenic artery were tied. This disadvantage applies to any operation in which the spleen is not removed. The following case illustrates this point. In this patient a splenic artery ligation was attempted and abandoned because the artery could not be found. Splenectomy was car-

FIG. 1

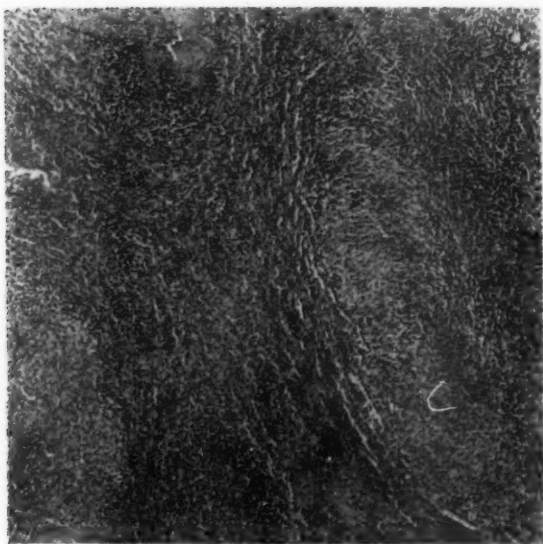
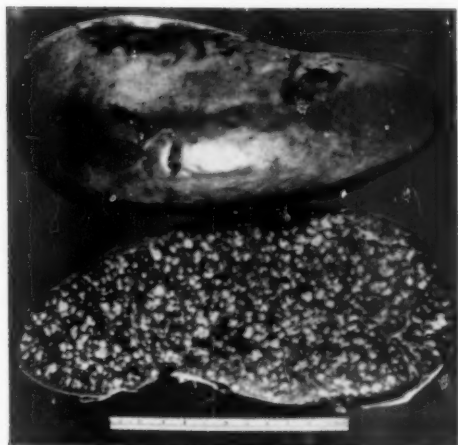


FIG. 2

FIG. 1.—Case mentioned in Discussion: Splenectomy was carried out after attempt to ligate the splenic artery was abandoned. Clinical diagnosis was cirrhosis with portal hypertension and Banti's syndrome. However, the spleen was found to be the site of a primary lymphoma unrecognized during the operation. External and cut surfaces of spleen show yellowish-white neoplastic nodules which have replaced parenchyma.

FIG. 2.—Photomicrograph showing edge of giant follicle in which change to Hodgkin's granuloma is apparent. Hematoxylin and eosin stain. $\times 40$.



LIGATION OF THE SPLENIC ARTERY

ried out and a splenic neoplasm discovered. In other clinics, a portacaval anastomosis might well have been performed, leaving the neoplasm *in situ*.

(A. B. H. No. 49-258) A 54-year-old white male was admitted to the hospital January 15, 1949, complaining of a swollen abdomen and legs of 5 weeks duration. He had been a heavy drinker for 12 years and had a recent episode of vomiting "coffee ground" material. Liver function tests revealed impairment of function and he exhibited numerous spider angiomas on the face, shoulders and chest. His total proteins were only 3.5 Gm. and his albumin-globulin ratio was reversed (serum albumin 2.5 Gm. and serum globulin, 1.0 Gm.). His hemoglobin was 14 Gm. (91 per cent), and the white cell count was 5,800. There were 64 per cent polymorphonuclear leukocytes and 36 per cent lymphocytes with no particular morphologic abnormalities. On January 26 the prothrombin concentration was 20 per cent of normal. Following paracentesis, the liver and spleen were found to be markedly enlarged to palpation. A diagnosis of Laennec's cirrhosis with portal hypertension and Banti's syndrome was made. It was also suspected that he had bleeding esophageal varices although this was not demonstrated by roentgenographic studies.

On January 19, splenic artery ligation was attempted because of the splenomegaly and the patient's generally poor condition. A careful and unsuccessful search for the splenic artery was made along the superior border of the pancreas. Possibly the artery was imbedded deep in the pancreas or was somewhere posterior to it. Splenectomy was done (A. B. III) and a spleen weighing over 1900 Gm. removed. The spleen measured 21 cm. in its greatest diameter (Fig. 1). On cut section, yellowish-white neoplastic nodules were seen diffusely distributed throughout the parenchyma. The histologic features of Hodgkin's disease developing in a giant follicular lymphoma were present (Fig. 2). This lymphoma was apparently primary in the spleen.

In addition to the first operation performed by the senior author cited previously in this communication, the following authors who have performed splenic artery ligation should be mentioned:

1. *Allebrandi of Rome, Italy.*¹⁰ Sixteen splenic artery ligations up to 1938 were reported. He was especially pleased with his results in the two patients in his series who had Banti's syndrome.
2. *Watson of England.*¹¹ In a 26-year-old woman with splenic enlargement since the age of seven years and with marked preoperative ascites and bouts of hematemesis, ligation of the splenic artery reduced the ascites. Abdominal paracentesis was less frequently required and the patient was healthy and working without hematemesis three years later.
3. *Berg and Rosenthal of New York.*¹² These authors ligated the splenic artery in three patients with splenomegaly due to cirrhosis of the liver. All patients had had hematemesis preoperatively. While all patients were dead within a three-year period, one patient was greatly improved until a massive hematemesis three years postoperatively. The other two patients died within a year, one after subsequent splenectomy.
4. *Maggiore in 1941*¹³ reported favorable results in splenic artery ligation for splenomegaly due to cirrhosis.
5. *Everson and Cole of Chicago,*⁶ already cited, deserve credit for re-emphasizing this operation to surgeons in this country. One of their three patients with splenomegaly due to cirrhosis improved immediately postoperatively and

was well one year later. The second patient was improved and alive three years after operation, although ascites persisted. The third patient died four months after ligation. In all three patients omentopexy was performed in addition to splenic artery ligation, but improvement was not believed to have been due to this procedure.

6. *Linton and Hardy of Boston.*¹⁴ Recently Hardy suggested splenic artery ligation as a first-stage procedure in a two-stage spleno-renal anastomosis for poor risk patients with portal hypertension. This was carried out in a 50-year-old man with cirrhosis of the liver and continued esophagogastro-intestinal bleeding. A month later, the patient was re-admitted to the hospital and a splenectomy and end-to-side spleno-renal shunt were performed. The patient withstood the second stage well. These authors stated in August, 1949¹⁴ that in their opinion the patient could not have withstood the shunting operation if it had been done without the previous splenic artery ligation.

SUMMARY

In our present series, two patients had Banti's syndrome unassociated with obvious hepatic cirrhosis. The first of these has survived and was well 34 years postoperatively. The second patient was completely well for one year. Jaundice and other symptoms possibly due to gallstones are now impairing her health two years postoperatively and further operative procedures will be necessary.

Three patients had splenomegaly due presumably to portal hypertension, as definite cirrhosis of the liver was present concomitantly. The first of these is well more than two years postoperative without recurrence of ascites. The second patient died four months after operation with recurrence of ascites. In this case, the patient was unco-operative after operation and would not submit to paracentesis. The third is well more than ten months after operation.

CONCLUSIONS

1. Ligation of the splenic artery, first studied experimentally, and first performed for Banti's syndrome in 1913 by the senior author, has never been a widely employed operation but deserves broader application and more frequent use than heretofore.
2. The history, rationale, technic and results of this operation have been reviewed and its present indications defined.
3. Results in five cases have been presented.
4. Ligation of the splenic artery is the operation of choice in selected (poor risk) patients with splenomegaly due to portal hypertension, Banti's syndrome and occasionally other splenopathies.
5. In patients with portal hypertension, if spleno-renal anastomosis cannot be carried out because of the patient's condition or the surgeon's lack of experience with this operation, splenic artery ligation is preferable to splenectomy. There is less interference with anastomotic venous pathways and subsequent spleno-renal anastomosis will be easier if the patient's improvement permits.

LIGATION OF THE SPLENIC ARTERY

BIBLIOGRAPHY

- 1 Blain, A. W.: Ligation of the Splenic Artery for Banti's Disease. Report of Case, Experimental Studies. Surg., Gynec. & Obs., **26**: 660, 1918.
- 2 Whipple, A. O.: The Problem of Portal Hypertension in Relation to the Hepato-splenopathies. Ann. Surg., **122**: 449, 1945.
- 3 Blakemore, A. H.: Portacaval Anastomosis: A Report on Fourteen Cases. Bull. New York Acad. Med., **22**: 254, 1946.
- 4 Blalock, A.: Use of Shunt or By-Pass Operations in Treatment of Certain Circulatory Disorders Including Portal Hypertension and Pulmonic Stenosis. Ann. Surg., **125**: 129, 1947.
- 5 Carter, B. N.: The Combined Thoraco-Abdominal Approach with Particular Reference to Its Employment in Splenectomy. Surg., Gynec. & Obst., **84**: 1019, 1947.
- 6 Everson, T. C. and W. H. Cole: Ligation of the Splenic Artery in Patients with Portal Hypertension. Arch. Surg., **56**: 153, 1948.
- 7 Blain, A. W.: Ligation of the Splenic Artery. Progress Report of Case Operated 34 Years Ago for Banti's Disease with a Discussion of Present Indications. Alexander Blain Hosp. Bull., **6**: 152, 1947.
- 8 Collier, F. A., A. Blain, III and G. Andrews: Indications for and Results of Splenectomy. Charles C. Thomas, Springfield, Illinois. In Press.
- 9 Blain, A., III and M. Clapper: The Cruveilhier-Baumgarten Syndrome. New England J. M., **232**: 647, 1945.
- 10 Alessandri, R.: Experiences with Surgery of the Spleen: Report of Two Unusual Cases. J. Mt. Sinai Hosp., **4**: 489, 1938.
- 11 Watson, R. B.: Ligation of the Splenic Artery for Advanced Splenic Anemia. Brit. M. J., **1**: 821, 1935.
- 12 Berg, A. A., and N. Rosenthal: Ligation of the Splenic Artery for Thrombocytopenic Purpura and Congestive Splenomegaly. J. Mt. Sinai Hosp., **8**: 382, 1942.
- 13 della Maggiore, B. D.: Cited by T. C. Everson, and W. H. Cole.⁶
- 14 Linton, R. R., and I. B. Hardy, Jr.: Surgery of Portal Hypertension. Portacaval Shunts and a Two-Stage Method in the Poor Risk Patient. J. Michigan State M. Soc., **48**: 1005, 1949.

BOOKS RECEIVED

BRUNNER, A.
HENSCHEN, C.
HEUSSER, H.
JENTZER, A.
SCHURCH, O.
VEYRASSAT, J.

Lehrbuch der Chirurgie. Benno Schwabe & Co., Basle, Switzerland, 1949.

PRATT, GERALD H.

Surgical Management of Vascular Diseases. Lea & Febiger, Philadelphia, Pennsylvania, 1949.

KEYNES, GEOFFREY

The Portraiture of William Harvey. Henry Schuman, Inc., 20 East 70th Street, New York, New York, 1949.

BEDER, OSCAR EDWARD

Surgical and Maxillofacial Prosthesis. King's Crown Press, New York, New York, 1949.

BLOOD SUPPLY OF THE RECTOSIGMOID AND RECTUM*

MORRIS W. GREENBERG, M.D.

BROOKLYN, N. Y.

THE INCREASING POPULARITY of primary anastomosis after resection of the rectosigmoid and rectal segments has prompted an anatomic study of the blood supply to that area of the bowel. The main problem was to re-evaluate and appraise the blood vessel anastomosis between the most distal artery supplying the sigmoid, the sigmoidea ima, and the superior hemorrhoidal artery, and to check the validity of Sudeck's critical point. Sudeck¹ described a point on the inferior mesenteric artery located above the origin of the last sigmoid artery as the safest point for ligation to insure maintenance of blood supply after mobilization of the rectosigmoid and rectal portions of the gut. Generally, writers have agreed with this statement, but varied considerably in their terminology and in their description of the vascular configurations in this area. Callander,² as did Sudeck, placed the critical point proximal to the origin of the last sigmoid artery. David³ described it as being just distal to the origin of the sigmoid artery. Bacon⁴ stated that the point of ligation should be above the first sigmoidal branch.

This paper does not present a new terminology of the vascular arcades to add to the varied descriptions already given, but presents the anatomy as a comparative study with the findings of previous authors. Findings in the anatomic investigations in this article did not agree with Sudeck's findings of infrequent collateral circulation below his designated point, for 51.4 per cent of the dissected cases presented here showed definite anastomosis between the sigmoidea ima and the superior hemorrhoidal artery branches.

To study this problem, 74 autopsy specimens of all ages (newborn to 88 years) were examined. Specimens were removed en masse. The aorta was transected three inches above its bifurcation and the incision extended to the left across the mesosigmoid and ascending branches of the left colic artery to sever the upper sigmoid above the iliac crest. Then the entire mass of bowel with its mesentery was scooped off the posterior parietal wall and ureter down to and across the anus and the prostate or uterus. The specimen was freed by an incision through the peritoneum to the right of the vessels. When the entire abdominal contents had been removed at one time, the specimen was obtained easily from a posterior approach. The prostate and bladder or uterus and bladder were then cut away as irrelevant in most instances. The lumen of the gut was washed free of fecal matter and the cut ends of the

* Abstract of thesis submitted to the faculty of the Graduate School, New York Medical College and Flower-Fifth Avenue Hospitals in partial fulfillment of the requirements for the degree of Master of Medical Science (in Surgery). Submitted for publication June, 1949.

left colic artery branches were ligated. The anal end of the gut with its transected vessels was ligated about one centimeter from its end.

For injection, a thin creamy suspension of barium sulphate in acacia and water was prepared. With a 20 cc. Luer syringe this liquid was injected, either with or without aid of a 19-gauge needle, directly into the aortic origin of the inferior mesenteric artery. Leaking points at either end of the specimen were clamped and ligated as they appeared. Twenty-seven specimens were clamped below Sudeck's point before injection, and 12 of these were injected under a controlled pressure of 150 to 180 mm. Hg. Roentgen ray photographs of the 74 injected specimens showing the arterial patterns and distribution formed the basis of this study.

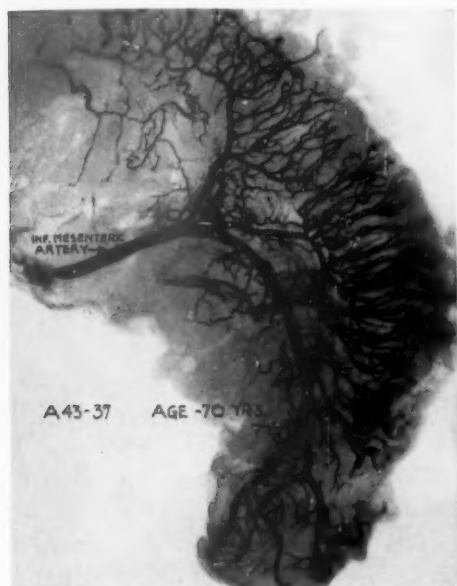


FIG. 1

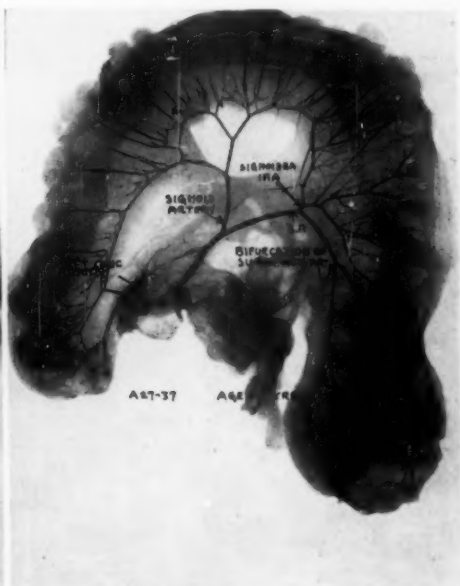


FIG. 2

FIG. 1.—Absence of left colic and marginal arteries.

FIG. 2.—Single sigmoid artery (26 per cent of cases). Typical sigmoidea ima. S. P.: Sudeck's critical point.

Interest was mainly centered in the following:

- Origin of the left colic artery.
- The number of sigmoidal arteries and their derivation.
- Marginal artery of Drummond.
- Rectosigmoid arteries.
- Sigmoidea ima artery, and its importance in the blood supply of the rectosigmoid area.
- Critical point of Sudeck, its surgical value, a re-study.

Left colic artery. There was no left colic artery as a branch of the inferior mesenteric artery in only one case in this series (Fig. 1). In 53 cases the

artery arose as a primary stalk, whereas 20 other specimens (27 per cent) demonstrated a combined origin of the left colic and a sigmoid artery. Drummond⁵ found that combined derivations were present in 11 of 20 instances, or 55 per cent.

Sigmoid arteries. The configuration of the sigmoid arteries showed the greatest variations. This explained the many different descriptions found in our basic anatomy texts. Babcock⁶ described a single sigmoid artery. Cunningham⁷ mentioned that there are usually two sigmoid arteries. Gray⁸ and Morris⁹ stated there are two to three in number, and Grant¹⁰ mentioned two to four. Our material of 74 specimens had one to four sigmoid arteries arising as main branches from the inferior mesenteric or left colic arteries.

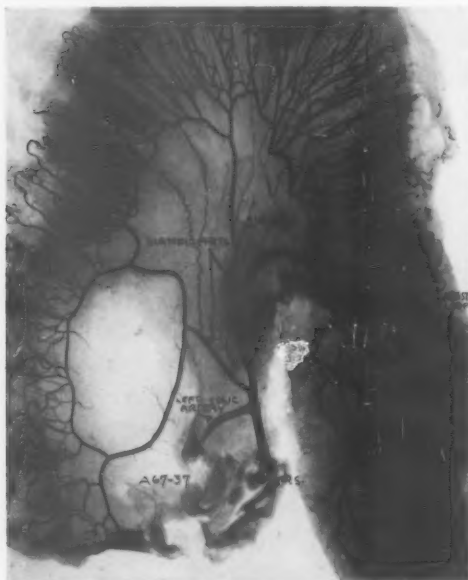


FIG. 3

FIG. 3.—Two sigmoid arteries (36 per cent of cases). Good marginal artery. Note the large anastomotic loop below Sudeck's point from the sigmoidea ima to the superior hemorrhoidal branch.

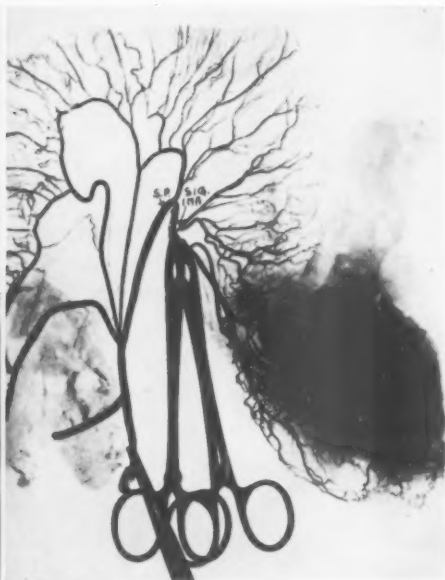


FIG. 4

FIG. 4.—Three sigmoid arteries (19 per cent of specimens). One bifurcates near its origin. The clamp was applied before the injection of the inferior mesenteric artery. There is complete filling below the block, demonstrating good anastomosis between the sigmoidea ima and superior hemorrhoidal branches.

Many of these sigmoid arteries split near their origin into two or more large divisions, however. In 19 cases (26 per cent) there was a single sigmoid artery; in 27 cases (36 per cent) two branches were present; 14 specimens (19 per cent) had three branches; and 14 cases (19 per cent) had four divisions (Figs. 2-5). Most authors stated that the sigmoid arteries were derived directly from the inferior mesenteric artery. However, in this study origin of one or more sigmoids from the left colic artery was common (27 per cent).

Marginal artery of Drummond. Anatomically, this had been described as a series of anastomotic vascular loops extending from the end of the ileum to

the terminus of the pelvic colon. In our series, the marginal artery occurred in the form of scalloped arcades mostly to the second degree, rarely to the third degree, and terminated distally in the sigmoidea ima artery. No marginal artery could be delineated in only one case. Here the major divisions bifurcated and then sent out terminal branches to the sigmoid and rectosigmoid (Fig. 1).

Rectosigmoid arteries. Buie¹¹ stressed the presence of one or more rectosigmoid arteries that supply the upper fifth of the rectum. The sigmoidea ima was probably included in this grouping. If, however, the sigmoidea ima were regarded as a separate entity, then in these specimens, independent rectosigmoid arteries were rarely found arising directly from the superior hemorrhoidal artery before its bifurcation. Fine thread-like mesenteric branches should not be regarded as rectosigmoid arteries. Distinct branches were seen in nine cases (12 per cent). Nevertheless this rectosigmoid zone was plentifully supplied with blood vessels either from the anterior branch of the superior hemorrhoidal after bifurcation, the descending branch of the sigmoidea ima, or the lowest sigmoid in the rare instance where the sigmoidea ima was absent.

Sigmoidea ima. Callander included this branch with the sigmoidal group of vessels, but David, and Rankin, Barger and Buie¹² described the sigmoidea ima as a distinct structure. In our work it was also regarded as a separate branch and the lowest sigmoid was considered as being an adjacent proximal branch. The sigmoidea ima was a rather constant artery which arose as an individual entity from the inferior mesenteric or superior hemorrhoidal in 64 cases (86.5 per cent), or just beyond its bifurcation in four cases (5.4 per cent) (Figs. 2-8). It was absent in only six specimens (8.1 per cent). Among the adults it arose about one to three cm. above the main bifurcation of the superior hemorrhoidal artery. Any branches above were regarded as sigmoid arteries. Generally, the root of the sigmoidea was short, measured about one-half a centimeter in length, and divided into two large branches at right or obtuse angles to the main stem. The upper division was usually well formed and supplied the upper rectosigmoid area with its terminal branches. It then continued as a well-formed recurrent artery to anastomose with the adjacent sigmoid artery to complete the lowest arcade of the marginal artery in 60 cases (81 per cent). Drummond, in his series of 20 specimens, found this anastomosis present in ten, absent on two occasions, and insignificant in eight others.

The lower division of the main stalk of the sigmoidea ima was as large as the upper, and supplied the upper part of the rectum. It anastomosed to a variable degree with the branches of the superior hemorrhoidal artery. Fine anastomoses could not be demonstrated with certainty by this photographic method because of overlapping, therefore only the obvious anastomoses were regarded as positive findings (Figs. 3, 6).

To demonstrate further the link between the sigmoidea ima and the superior hemorrhoidal arteries, 27 inferior mesenteric arteries were dissected preliminary to injection. The dissection could not be too extensive lest anastomotic

branches be torn. The superior hemorrhoidal artery was clamped between the sigmoidea ima and the bifurcation of the superior hemorrhoidal; the inferior mesenteric artery was then injected with the liquid barium sulphate suspension. The difficulty in locating this point was demonstrated by the inadvertent clamping of three specimens below the bifurcation. Those cases where the sigmoidea ima arose close to the superior hemorrhoidal bifurcation or from one of the bifurcations itself, the clamp had to be proximal to the ima, *i.e.*, between the lowest sigmoid branch and the hemorrhoidal bifurcation.

Twenty-four specimens were considered in this series where the superior hemorrhoidal artery was clamped before injection. Here, 13 photographs showed an excellent anastomosis between the lower division of the sigmoidea

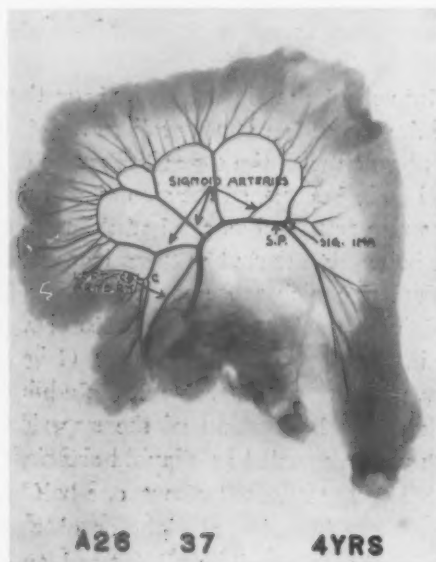


FIG. 5

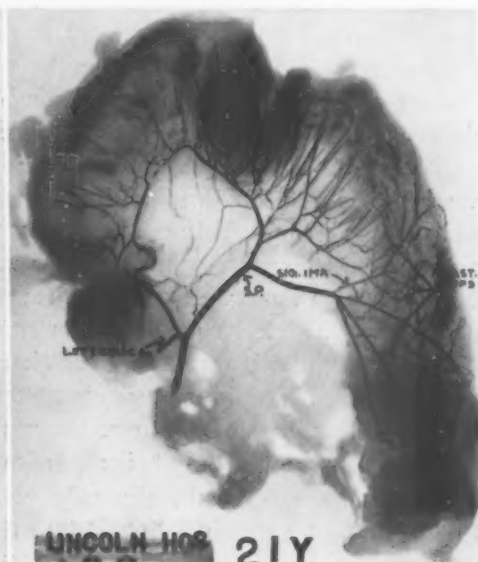


FIG. 6

FIG. 5.—Four sigmoid arteries (19 per cent of specimens). No demonstrable anastomosis below Sudeck's point was found in 48.6 per cent of cases.

FIG. 6.—Multiple anastomoses to superior hemorrhoidal branches from sigmoidea ima and lowest sigmoid artery.

ima and the superior hemorrhoidal (Figs. 4, 7), and 11 films showed poor or no anastomosis. Especially good filling was noted in those cases where the sigmoidea ima originated from a branch of the superior hemorrhoidal artery, *i.e.*, beyond the bifurcation of the superior hemorrhoidal artery (Fig. 8).

Of the 11 cases injected under controlled pressure of 150 to 180 mm. Hg. which were included in the series of 24 above, two showed good anastomosis, but nine others showed none. However, when some of these nine specimens were later injected with a syringe without controlled pressure, or dissected clearly, anastomotic connections, previously not obvious, became evident. As this study was basically anatomic, and every factor *in vivo* could not be simu-

lated, all anastomoses shown by any method were regarded as existent, and were so tabulated.

In the series of 74 specimens, 38 or 51.4 per cent showed definite anastomosis either between the inferior division of the sigmoidea ima and branches of the superior hemorrhoidal artery, or between the lowest sigmoid artery and sigmoidea ima when the latter arose from beyond the bifurcation of the superior hemorrhoidal artery. If ligation were performed at this level, *i.e.*, below Sudeck's point, the distal segment of rectum should not be deprived of an anatomic blood supply. In the other 36 cases, or 48.6 per cent, where no collateral circulation was demonstrated, such a ligation would surely compromise the distal bowel segment.

Age influenced the above calculations, for there was a distinct tendency towards poorer collateral circulation in the patients above 60 years.

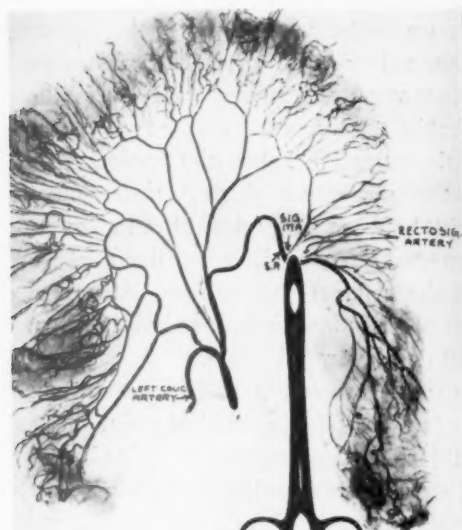


FIG. 7

FIG. 7.—Good collateral circulation below critical point.



FIG. 8

FIG. 8.—High origin of sigmoid arteries and low origin of sigmoidea ima showing good collateral circulation around obstruction of large intervening segment of inferior mesenteric artery. Note proximity of Sudeck's point to origin of inferior mesenteric artery.

Sudeck, quoted by Bacon and Smith,¹³ found that when a ligature was placed below the origin of the lowest sigmoid artery (the sigmoidea ima of this paper), few, if any, of the rectal vessels filled. Grant,¹⁰ Callander,² Wangenstein,¹⁴ Archibald¹⁵ and Sunderland¹⁶ all agreed with Sudeck when they stated that the marginal artery of Drummond did not link up the lowest sigmoid with the superior hemorrhoidal except occasionally and feebly, so that if the superior hemorrhoidal artery were obstructed beyond the origin of the lowest sigmoid, there was little chance of an effective collateral circulation being established.

The material presented here was at variance with the findings quoted

above, because in this series 51.4 per cent showed good anatomic anastomosis below Sudeck's point. From this study, it seemed that consistent gangrene encountered postoperatively in mobilization of this portion of the large gut might not always be due to anatomic vascular deficiencies. Perhaps the slough that had been described in performing the lower ligations was due more to tension, as Drummond suggested, and not to anatomic avascularity. Mahorner,¹⁷ however, presented three cases of gangrene in which the superior hemorrhoidal artery was ligated at the promontory of the sacrum and the rectum pulled through; and in other cases where the superior hemorrhoidal was not ligated there was no slough. In Mahorner's cases we do not know the exact points of ligation in the vascular tree, although one surmises that ligation at the promontory is usually above Sudeck's critical point. This was brought out in the photographs presented in this article, where the location of the superior hemorrhoidal artery bifurcation was five to eight cm. from the floor of the pouch of Douglas, or halfway up to the promontory of the sacrum. As the origin of the sigmoidea ima was only one to three cm. above this bifurcation, and therefore below the promontory of the sacrum, then in Mahorner's cases Sudeck's point was probably not involved and gangrene was most likely influenced by other factors than ligation below the critical point. Bacon's method of transilluminating the mesentery during operation to demonstrate the vascular patterns could be very helpful in localizing and recording the exact point of ligation so that postoperative results could be evaluated better. Transillumination on the cadaver was not so satisfactory, especially for determining the bifurcation of the superior hemorrhoidal artery. The arcades on the other hand were well demonstrated.

Dixon,¹⁸ in discussing low anterior rectal resection and primary anastomosis, says: "my colleagues and I do not recognize any critical point in this determination" (point of ligation of the inferior mesenteric or superior hemorrhoidal vessels), "rather depending on the precepts of rational cancer surgery and providing the correct amount of excision to allow the sigmoid or descending colon, as the case may be, to reach or bridge to the rectal or rectosigmoid transection without tension. . . . The rectal stump can survive if supplied by the inferior hemorrhoidal vessels alone, . . . secondly, Sudeck's point is not as critical as described."

This study demonstrated that by injecting an artery under pressure, anatomic anastomoses could be demonstrated which might or might not be adequate clinically to carry the requisite arterial supply. This must be considered in estimating the clinical application of such findings. Steward and Rankin¹⁹ have also cautioned against drawing conclusions regarding vascular potentialities. Autopsy specimens have completely relaxed arteries subject to higher internal pressure than normal and may give erroneous data at variance with the true condition during life. Attempting to guard against this error, controlled pressure of 150 to 180 mm. Hg. was used in 11 specimens. However, there must be other more important factors involved than pressure alone, because some obvious shunts were not demonstrated by this technic, and were

only disclosed by actual dissection or further injection with a syringe without regard to pressure level control. Therefore measured pressure was disregarded in this entire series.

Clinical application of this anatomic study as related to surgery of the rectosigmoid and rectal areas must be influenced by the above considerations. Nevertheless, the results of this study demonstrating anastomosis between the sigmoidea ima or lowest sigmoid artery and the divisions of the superior hemorrhoidal artery in 51.4 per cent, should make one re-investigate the possible causes of gangrene of the bowel in ligations of the inferior mesenteric artery below Sudeck's critical point.

CONCLUSIONS

1. There are many variations in the configurations of the vascular tree of the inferior mesenteric artery.
2. The sigmoidea ima is a rather constant artery supplying the rectosigmoid and upper rectum and anastomoses with the adjacent sigmoid artery to complete the arcade of the marginal artery of Drummond in 81 per cent of specimens.
3. There is an adequate anatomic linkage between the sigmoidea ima or lowest sigmoid and the superior hemorrhoidal artery divisions in 51.4 per cent of cases. This figure is higher than that given by most previous authors.
4. Since this study is purely an anatomic one, clinical implications must be influenced by the inherent differences between necropsy material and operative and postoperative experiences.

BIBLIOGRAPHY

- 1 Sudeck, P.: *Über die Gefassversorgung des Mastdarmes in Hinsicht auf die operative Gangran.* *Munchener medizinische Wochenschrift*, **54**: 1314, 1907.
- 2 Callander, C. L.: *Surgical Anatomy*, 2nd Edition, page 392, 1943. W. B. Saunders Co., Phila.
- 3 Lewis, D.: *Practice of Surgery*, vol. VII, chap. 6, page 13. 1947, W. F. Prior Co., Hagerstown, Md.
- 4 Bacon, H. E.: *Anus, Rectum and Sigmoid Colon*, 2nd Edition, page 632. 1943, J. B. Lippincott, Phila.
- 5 Drummond, H.: *The Arterial Supply of the Rectum and Pelvic Colon.* *Brit. J. Surg.*, **1**: 677, 1913-14.
- 6 Babcock, W. W.: *Textbook of Surgery*, 7th Edition, page 1049. 1935, W. B. Saunders Co., Phila.
- 7 Cunningham, D. J.: *Textbook of Anatomy*, 7th Edition, page 1211. 1937, Oxford University Press.
- 8 Gray, H.: *Anatomy of the Human Body*, 24th Edition, page 610. 1944, Lea and Febiger, New York.
- 9 *Morris's Human Anatomy*: Edited by Schaeffer, J. P.: 10th Edition, page 672. 1946, The Blakiston Co.
- 10 Grant, J. C. B.: *Method of Anatomy*, 3rd Edition, page 253. 1944, Williams and Wilkins Co., Baltimore.
- 11 Buie, L. A.: *Practical Proctology*, page 63. 1938, W. B. Saunders Co., Phila.
- 12 Rankin, F. W., J. A. Barga and L. A. Buie: *Colon, Rectum and Anus*, page 33. 1935, W. B. Saunders Co., Phila.

- ¹³ Bacon, H. E., and C. H. Smith: The Arterial Supply of the Distal Colon Pertinent to Abdominal Proctosigmoidectomy. *Ann. Surg.*, **127**: 28, 1948.
- ¹⁴ Wangenstein, O. H.: Primary Resection of Rectal Ampulla for Malignancy with Preservation of Sphincteric Function. *Surg. Gynec. & Obst.*, **81**: 1, 1945.
- ¹⁵ Archibald, E.: Operative Treatment of Cancer of the Rectum. *J. A. M. A.*, **50**: 573, 1908.
- ¹⁶ Sunderland, S.: Blood Supply of the Distal Colon. *Australia & New Zealand J. Surg.*, **11**: 253, 1942.
- ¹⁷ Mahorner, H.: Restoration of Continuity after Resection of the Rectum. *Ann. Surg.*, **123**: 866, 1946.
- ¹⁸ Dixon, C. F.: Anterior Resection for Malignant Lesions of the Upper Part of the Rectum and Lower Part of the Sigmoid. *Ann. Surg.*, **128**: 429, 1948.
- ¹⁹ Steward, J. A., and F. W. Rankin: Blood Supply of the Large Intestine: Its Surgical Considerations. *Arch. Surg.*, **26**: 843, 1933.

UROLOGY AWARD

The American Urological Association offers an annual award of One Thousand Dollars (first prize of \$500.00, second prize \$300.00 and third prize \$200.00) for essays on the result of some clinical or laboratory research in Urology. Competition shall be limited to urologists who have been in such specific practice for not more than five years and to residents in urology in recognized hospitals.

The first prize essay will appear on the program of the forthcoming meeting of the American Urological Association, to be held at the Hotel Statler, Washington, D. C., May 29 — June 1, 1950.

For full particulars write the Secretary, Dr. Charles H. de T. Shivers, Boardwalk National Arcade Building, Atlantic City, N. J. Essays must be in his hands before February 20, 1950.

THE NEUROLOGIC DEFICIT ASSOCIATED WITH LIPOMAS OF THE CAUDA EQUINA*

ROBERT C. BASSETT, M.D.

ANN ARBOR, MICHIGAN

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF MICHIGAN
MEDICAL SCHOOL AND HOSPITAL, ANN ARBOR

CONGENITAL DEFECTS of the vertebral axis are among the most common brought to the attention of the neurologic surgeon. For this reason, knowledge of their management has been well established. However, within this group of lesions a not unusual and certainly not a rare type of anomaly seems to have been by-passed since little concerning its specific management and troublesome sequelae is apparent in the literature.¹⁻⁷

We refer to those benign tumors of lipomatous tissue in the lumbosacral region resulting from mesenchymal proliferative changes and ectodermal inclusion at the time of closure of the neural tube in the embryo.

The problem is worthy of discussion since the severity of later symptoms may be, and often is, extensive and incapacitating.^{2, 3, 5} Too often through lack of understanding, the importance of early surgical treatment remains unstressed and the patient returns only after the onset of symptoms—frequently with an irreversible neurologic deficit.

ETIOLOGY

These lesions are almost always pure collections of fat not associated with abnormal defects of the meninges (meningoceles), although occasionally they may be. They are continuous with the subcutaneous fatty layers in the gluteal regions and nearly always penetrate the dura and are attached to the conus. A considerable mass of fatty tissue may be present intradurally even though the opening into this structure may be small or absent.⁷

These lipomas may be considered a double error in the dynamics of development; *i.e.*, overabundant growth of the source of fat plus inclusion of either rests or projections of the overabundant fat layers at the time of closure of the neural tube.⁶

PATHOLOGIC ANATOMY

Upon gross examination there appears in the midline or closely to one side a tumescence covered with normal skin. It is soft but not fluctuant and one is aware of the continuity of the tumor with the subcutaneous fat over the glutei (Figs. 2 and 5). Normal healthy fat is seen throughout the cut section. Histologically this impression is substantiated and only in those portions of the abnormal structure adjacent to or contiguous with the defect within the neural arches, dura, and conus does one encounter islands of cartilage or aberrant neural elements of no functional consequence (Fig. 1).

* Submitted for publication February, 1949.

MECHANISM OF PRODUCTION OF SYMPTOMS AND SIGNS

Until approximately the third intrauterine month the spinal cord and vertebral column approximate each other throughout their lengths. At this time due to skeletal development the proportion is lost and a relative cephalad migration of the cord occurs. At term the conus is situated approximately at the level of the fourth lumbar body. This relative cephalad migration of the cord continues until the growth period terminates, at which time the conus rests opposite the twelfth thoracic or first or second lumbar bodies. Therefore with fixation of the conus by the congenital lipomatous anchor it is readily seen that as growth progresses, greater and greater traction will be applied to the conus and cauda equina (Fig. 3).

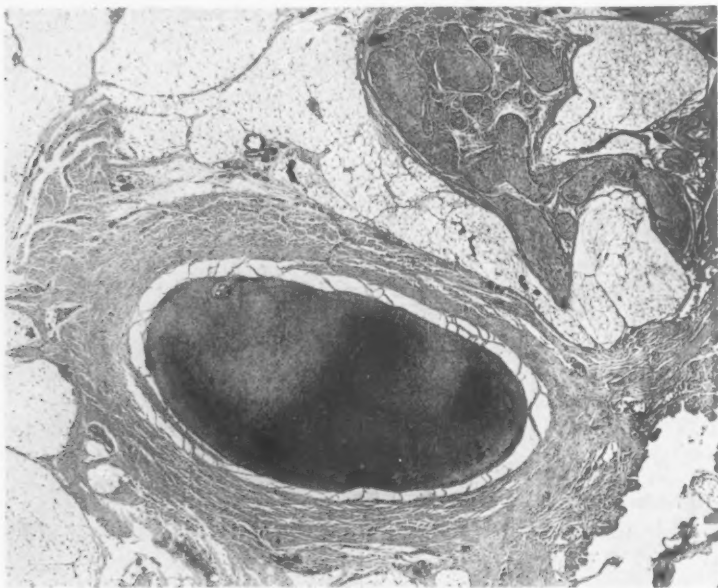


FIG. 1.—Microphotograph showing cartilaginous and aberrant neural elements in lipoma near attachment to conus.

Another factor bringing about production or accentuation of symptoms is the accumulation of added fat. Since the abnormally placed tissue is undergoing normal metabolism, its mass is directly proportionate to the patient's nutritive state. Therefore signs and symptoms may be influenced with excessive weight gain or loss (Case 1).

Case 1.—S. L., a 13-year-old female, was first seen on May 23, 1934, with the chief complaint of urinary incontinence. A soft mass approximately 10 cm. in diameter was present over the sacrum. At its apex there was a tuft of hair. Roentgenograms demonstrated bifid deformity of the entire sacral canal. There were no sensory or motor changes except for loss of tone of bladder sphincter. Surgical treatment was advised. The patient returned 4 years later still suffering urinary incontinence night and day, and in addition

FIG. 2

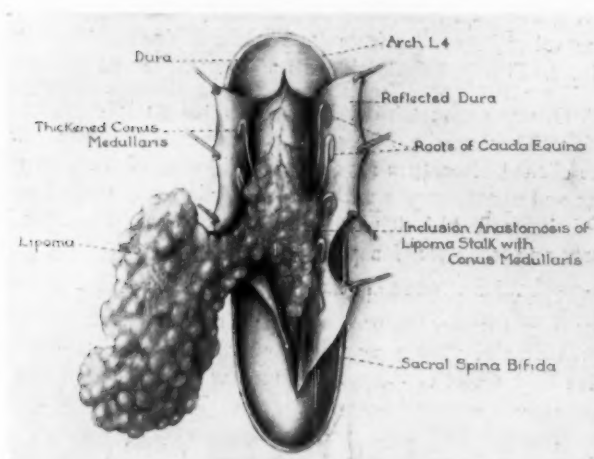
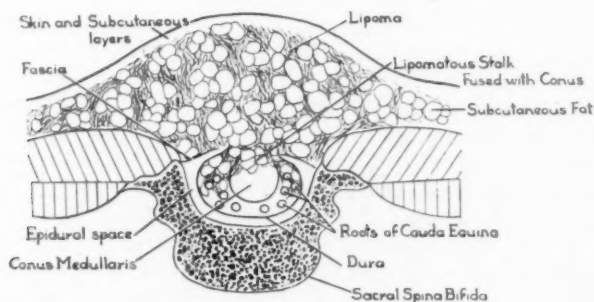


FIG. 3

FIG. 3.—Diagram showing mechanism of traction deformity of conus and roots of cauda equina.

Case 2.—S. T., a 5-month-old female, was first seen on January 28, 1942, with a fatty mass 12 by 6 cm. to the right of the midline over the sacrum. Roentgenograms

revealed dislocation of the right innominate bone upward and bifid deformity of the sacral arches. There was relaxation of the anal sphincter. Operative treatment was contemplated but not undertaken. She was returned in January, 1944, with constant urinary dribbling, constipation and flaccid weakness of the right leg. On February 1, 1944, the typical lipomatous tumescence was removed by delineating the stalk penetrating the dura and resecting its coalescence with the conus. The upper roots of the cauda equina were seen to sweep cephalad to their foraminae of exit. None of these structures was damaged. Postoperatively the patient developed a wound infection and expired on the nineteenth postoperative day of pneumococcus Type XX meningitis.

Case 3.—B. R. was a 15-year-old school girl, first seen on June 22, 1944, with a 12 by 12 cm. mass over the sacrum. She had had nocturnal enuresis for as long as she could recall and voided at half-hourly intervals during the day. She also suffered dribbling incontinence. Four years previous to admission she began experiencing sharp shooting pain in the left buttock and calf relieved only by lying down. Flaccid weakness, one inch atrophy of the left leg, saddle anesthesia, relaxed bladder tone and loss of pain and temperature sensation in this organ were predominant findings. Roentgen rays disclosed bifid deformity of all sacral segments. On June 30, 1944, the typical deformity was removed by delineating the stalk penetrating the dura and sharply dissecting it from the conus. The postoperative course was uneventful. She returned six months later with findings unchanged, except that cystometric examination of the urinary bladder was normal. The left sciatic pain had persisted and increased in intensity. On February 13, 1945, further removal of fatty tissue from the extradural space and the tip of the intradural sac was carried out. Postoperatively she was asymptomatic and has not been seen since.

Case 4.—B. O. was a 2-month-old female admitted on July 31, 1944, by her grandfather, a physician. There was a 6 by 4 cm. mass over the sacrum. No other objective findings could be elicited. Roentgen rays showed widening of the interpedicular spaces of the lower lumbar and upper sacral vertebrae. The lesion was excised on August 2, 1944, by delineation of the stalk and sharp dissection from the conus. The patient has been followed regularly and is perfectly normal to date.

Case 5.—K. R. was a 5-year-old female admitted on January 9, 1945, with a 12 by 10 cm. soft mass over the sacrum, present since birth, and nocturnal enuresis. The left Achilles jerk was absent. There were no other objective findings. Roentgenograms revealed extensive bifid defect of the lower 3 lumbar and all sacral arches. On January 13, 1945, the lipoma was dissected from the conus. The postoperative course was complicated by a cerebrospinal fluid leak. She was discharged 2 months postoperatively. The patient returned one year later, completely asymptomatic, and remained so until January 19, 1948, when she complained of pain in the operative site. The mother had noticed recurrent tumescence. Other than increased tumescence there were no other objective findings. Pantopaque myelography revealed a space taking defect at the fourth and fifth lumbar vertebrae and at operation a spurious meningocele—a sequel to the previous cerebrospinal fluid leak—was discovered and repaired. Recovery was uneventful.

Case 6.—J. G., a 16-month-old female, was admitted on March 4, 1945, with a 5 by 3 cm. soft mass over the sacrum. There were no detectable neurologic changes. A roentgenogram was not taken. On March 5, 1945, the lipomatous stalk was delineated traversing the dura. Within the stalk was a walnut-sized meningocele containing a few aberrant neural elements. The stalk was freed from the conus. The postoperative course was uneventful.

Case 7.—S. R., a 15-month-old female, (sister of Case 4) was admitted on July 26, 1945, with a 6 by 7 cm. soft mass over the sacrum. There was a palpable spina bifida above the mass. She had constant urinary dribbling. There were no detectable neurologic

LIPOMAS OF THE CAUDA EQUINA

changes. Roentgen ray demonstrated an extensive bifid defect of all lumbar and upper sacral segments. On July 31, 1945, the lipoma was resected from the conus. The postoperative course has been uneventful.

Case 8.—M. S., a 2-month-old female, was seen on February 1, 1944, with a soft mass over the sacrum just to the left of the midline. There were no demonstrable neurologic deficits. Operation was deferred for weaning. She returned on April 10, 1945, at age 16 months. The mass measured 7 by 7 by 4 cm. There was bilateral footdrop and atrophy of both calves. All deep tendon reflexes were absent in the lower extremities. Sensation was absent in the saddle and postero-medial aspects of thighs, calves and feet. She was constantly wet and she was unable to stand. Roentgenograms demonstrated malformation and incomplete fusion of the arches of lumbar vertebrae 3, 4 and 5. On April 16, 1945, the lipoma which presented the typical traction picture at the conus was excised. The postoperative course was uneventful. Three months later the picture was unchanged. One year later she was able to stand and walk with the aid of short double upright braces. Sensation was normal except for the lateral aspect of the soles of the feet. She was being catheterized three times daily.

Case 9.—E. D., a 19-year-old female, was first seen on October 20, 1931, with a 6 by 6 by 4 cm. fat pad just to the left of the midline. In the lower center of the mass was a fixed dimple. There was "stocking" hypesthesia of the left calf and foot to just below the knee. Deformity of the bony pelvis was discovered on gynecologic examination. Roentgen ray demonstrated angulation of the left lower half of the sacrum to the left and forward almost to the ischial tuberosity (Fig. 4). She was discharged at her request, since she had no symptoms referable to the lesion. She returned on January 8, 1946, having been delivered of a child by Cesarian section some six years before. Four months prior to admission she had a hard fall in the sitting position. Following this she had experienced constant stabbing pain in the midline over the sacrum, radiating to the mid-thigh on the right. The right half of the saddle was anesthetic and a band of hypesthesia involving the fourth and fifth lumbar segments was present over the entire right leg to the foot. Reflexes and motor power were normal. On January 11, 1946, the lipomatous mass was excised from the conus. The conus and cauda equina were in a less marked situation of traction than generally seen. However, the roots on the right had definitely more traction upon them than those on the left. Her postoperative course was uneventful. Fourteen months later she returned completely asymptomatic and without objective findings.

In every case, with the exception of the two-month-old infant treated surgically prior to the time when any degree of traction could be exerted upon the conus, moderate to severe neuropathy occurred.

It is interesting to note that all of these cases are females and that two cases are siblings whose father, by roentgen ray, was shown to have an occult bifid deformity of the lowest lumbar and first sacral vertebrae. This is suggestive evidence that these lesions may be more than congenital errors and that further they may be dominant in females and recessive in males.

DIAGNOSIS

These neuropathic changes are usually avoidable in all cases if the defect is corrected at an early date. There is little reason why this should not be feasible since the pathologic condition is obvious from birth. Only rarely is there any delay in the appearance of the abnormal fat pad.

The diagnosis is obvious with the combined picture of the soft but not fluctuant mass situated in or near the midline and covered with healthy skin and associated bifid deformity of the lumbosacral spine. Diagnosis is further substantiated with the picture of progressive peripheral neuropathy, disturbance of bowel and bladder function, pelvic skeletal, and trophic changes.

TREATMENT AND TECHNIC

Surgical relief of traction upon the conus and cauda equina is mandatory in every instance. These patients may go for years without symptoms as in



FIG. 4.—Film showing deformity of sacrum produced by lipoma of long standing in Case 9.

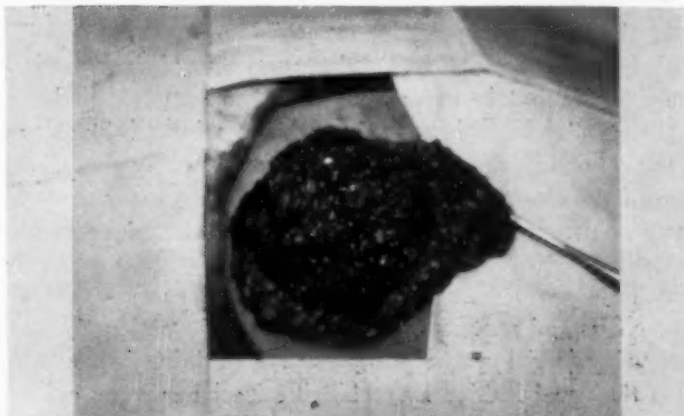
Case 9. However, she suffered skeletal deformity early, which prevented her delivering any pregnancy normally and became symptomatic only after trauma.

The mass of fat is exposed by a transverse incision through the skin (Fig. 5a). The skin flaps are then reflected and the periphery of the mass incised in circuitous fashion down to the lumbodorsal fascia. Here an anatomic cleavage plane presents, allowing delineating and mobilization of the lipomatous stalk as it traverses the defect in the fascia (Fig. 5b). If the bifid defect is not

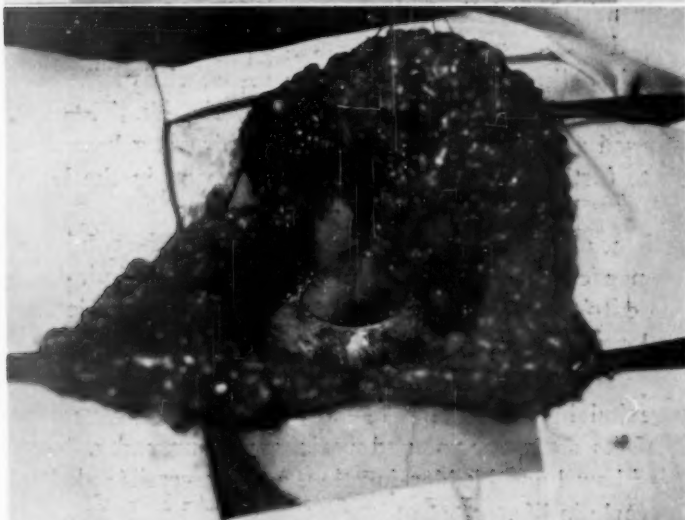
FIG. 5.—(A) Skin flaps reflected showing subcutaneous fatty tumor. (B) Tumor mobilized and lipomatous stalk delineated penetrating the deep fascia at site of bifid defect. (C) Tumor, stalk, and conus completely mobilized. Stalk should be excised no closer than one centimeter below the lowermost root.

LIPOMAS OF THE CAUDA EQUINA

A



B



C



FIG. 5.—(Legend on opposite page)

extensive, laminar arches adjacent to the stalk may have to be removed in order to open the dura in the midline.

When this latter is accomplished and the position of the conus ascertained the stalk may be severed in order to get the main tumor mass out of the way (Fig. 5c). Following this procedure that portion of the fatty stalk left attached to the conus may be more completely removed by sharp excision and judicious use of the electric cauterly—literally melting the fat away.

There may be multiple lobules of fat in and about the caudal roots which early can be teased away from these structures without damage to them. This may be virtually impossible in long standing cases.

When the conus and roots are seen to be free of traction the dura is then closed tightly using fascial grafts if necessary. The defect in the bony canal is then closed in the usual fashion by mobilizing fascial flaps on either side and embricating them in the midline.

In closing the skin, wide through and through mattresses of silk are employed to help obliterate the large dead space which is still lined with fat. The skin itself is closed with fine interrupted plastic silk. These patients are then placed on an anterior frame and a pressure dressing kept applied for at least a week to further control accumulation of serum in the large potential dead space.

These patients are to be warned of the possibility of the results of excessive weight gain, particularly those in whom it has been technically impossible completely to extricate the caudal roots from fat when the lesion has been present for a long time.

SUMMARY

The congenital lipomas of the lumbosacral region may produce serious neurologic deficits such as profound peripheral neuropathy, trophic ulcers, disturbances of bowel and bladder function, and irreversible skeletal changes, if not treated early in life.

The optimum time for treatment is during the first three or four months of life before strong mechanical traction can be exerted upon the conus and cauda equina.

Treatment is surgical.

BIBLIOGRAPHY

- ¹ Bassett, R. C.: Lipomas of the Cauda Equina. Univ. Hosp. Bull. Ann Arbor, 11: 26, 1945.
- ² Groff, R. A., and J. C. Yaskin: Late Occurrence of Sphincter and Other Neurological Disturbances Associated with Congenital Malformations of the Vertebral Column. Tr. Am. Neurol. A., 218, 1947.
- ³ Ingraham, F. D., and J. J. Lowrey: Spina Bifida and Cranium Bifidum. III. Occult Spinal Disorders. New England J. Med., 228: 745, 1943.
- ⁴ Johnson, A.: Pathol. Soc. London, Trans., 1856-57.
- ⁵ Mixter, W. J.: Spinal Column and Spinal Cord. Chap. 3 Dean Lewis Practice of Surgery. Vol. 12, W. F. Prior Co. Inc., Hagerstown, Md.
- ⁶ Patten, B. M.: Human Embryology. 1946, Blakiston Co., Phila.
- ⁷ Temoin, Daniel (deBourges): Arch. Prov. de Chirurg., 1893.

EXTRINSIC DUODENAL OBSTRUCTION IN THE NEWBORN*

ALLAN E. SACHS, M.D.

CHICAGO, ILLINOIS

FROM THE SURGICAL SERVICES OF MICHAEL REESE AND MOUNT SINAI HOSPITALS
AND THE DEPARTMENT OF SURGERY OF THE CHICAGO MEDICAL SCHOOL

ABDOMINAL SURGERY in the newborn infant is concerned mainly with the correction of congenital malformations and defects. An intimate knowledge of the exact nature of the anatomical disturbance is the all important factor in saving lives. This has been demonstrated by the splendid investigations of Ladd and Gross¹ in the condition of malrotation of the intestine. Here their anatomical studies along with those of Dott,² Gardner and Hart³ showed the way to an operation of low mortality rate instead of the highly fatal gastro-enterostomy in the poor risk infant.

Stenosis and atresia of the duodenum have been adequately described by Ladd and Gross¹ as well as others. Most of these cases have been due to incomplete lumen formation within the duodenum. However, the duodenum may be compressed by the adhesions from the cecum in malrotation of the large intestine. Obstruction due to other types of bands are mentioned but with no adequate description in the literature.

The following case represents an obstruction of both the duodenum and the common bile duct by an adhesive band accompanying an anomalous artery (Fig. 1).

Case 1.—This three pound, 12 ounce premature female infant, Baby S., was admitted to the Sarah Morris Children's Hospital of Michael Reese Hospital on September 15, 1945, the day of her birth. I first saw her on her fifth day of life. Since birth she had vomited projectily all of her feedings and had developed an increasing jaundice so that she was a severely dehydrated, deeply jaundiced, poor risk premature infant. Only meconium stools had been passed since birth. A thin barium mixture was fed to the baby by gavage method, and roentgen ray films revealed an obstruction just beyond the pylorus with only a small amount of barium trickling past.

Although surgical intervention was deemed very hazardous, it offered the only hope for life. The infant was prepared for abdominal exploration with subcutaneous 2½ per cent glucose in normal saline, 10 cc. per pound of body weight. With difficulty, a blunt end 20-gauge needle was tied into the saphenous vein just anterior to the internal malleolus prior to operation. The patient was anesthetized with drop ether poured on a mesh mask under which a catheter delivering oxygen was placed. Preoperative medication consisted of only 1/1000 of a grain of atropine sulphate subcutaneously. Vitamin K was also started in 2 mg. hypodermic doses daily.

A right paramedian incision was made, and upon opening the peritoneal cavity the stomach and duodenum were immediately identified. Both were moderately distended, but the distension ceased at the curve of the duodenum. Beyond this point, the duodenum was not only collapsed, but difficult to identify. Since the infant was jaundiced, the gallbladder was next explored and found to be considerably distended. The organ approximated an ordinary green grape in size, but this was thought to represent consid-

* Submitted for publication March, 1949.

erable distention in a premature infant of only three pounds. The liver was swollen and of a dark greenish color (See Fig. 1). The common duct was also thought to be dilated, although it was just barely palpable. Next, the anterior wall of the duodenum at the site of the obstruction was examined, and in freeing the wall a band was found compressing the wall. This band originated from the mesenteric root just over the pancreas and extended into the duodenal hepatic ligament. It carried a small artery which had to be ligated. After cutting the band and artery an attempt was made to milk gas past the site of the obstruction and along the duodenum. However, it was difficult to evaluate this test because of the small size of the structure. Therefore, a small opening was made in the

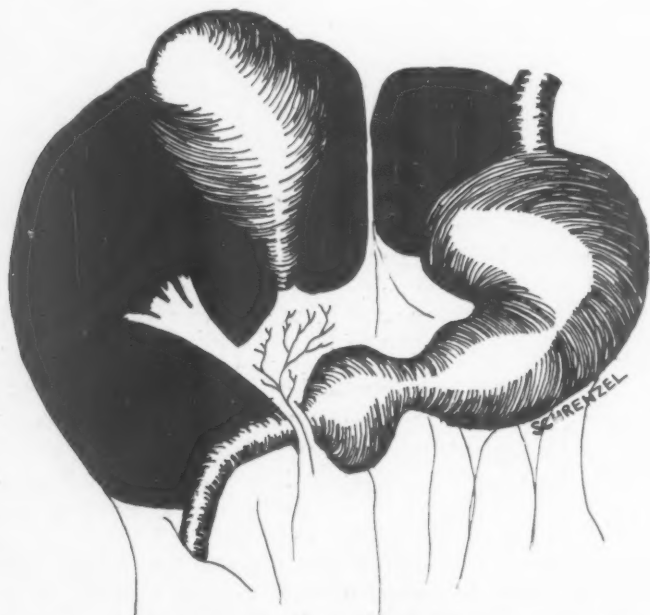


FIG. 1.—Semidiagrammatic representation of pathology found in Baby S. Note extrinsic band compressing the duodenum and common bile duct with dilated gallbladder and stomach.

anterior wall of the stomach and a No. 6 French catheter was threaded through the pylorus and down the duodenal lumen into the jejunum. This definitely demonstrated the patency of the lumen. At this point I decided that it might be better to leave this catheter in place as a means of feeding, since these infants are too weak to nurse well. Therefore, the catheter was fixed in the stomach wall by two purse string sutures of fine catgut on atraumatic needles. Because of the severe jaundice present along with the distended gallbladder, common duct, and swollen greenish liver, I also decided to do a cholecystostomy for the purpose of decompressing the biliary tract. The bile removed from the gallbladder was thick and dark. The cholecystostomy was accomplished with two purse string sutures and a No. 6 French catheter. Both catheters were brought out through stab wounds in the abdominal wall on their respective sides and the incision was closed in layers with fine catgut sutures.

Immediately after the operation, the baby was given a 40 cc. citrated blood transfusion followed by 250 cc. of 5 per cent glucose in normal saline via the cannula. The question of alimentation was somewhat of a problem as we knew of no previous jejunal feedings in so young an infant. The earliest feedings were of amigen, whiskey, and breast milk injected through the catheter in 2 dram amounts. By the second postoper-

EXTRINSIC DUODENAL OBSTRUCTION IN NEWBORN

ative day, the baby was maintained on just the tube feedings and pancreatin was added to the feedings in $\frac{1}{4}$ grain doses to aid digestion. Vitamins B and C were given along with the Vitamin K by the hypodermic route. The bile flowed freely from the cholecystostomy tube, and in 4 to 5 days the jaundice was no longer visible. The baby responded very well and on the eighth day the cholecystostomy catheter fell out of the wound. The fistula closed promptly. Then the stools developed a brownish color. After about ten days, oral feedings were started. These were tolerated well so the feeding tube was removed and the fistula into the stomach closed rapidly. The child made an uneventful and complete recovery.

Another type of duodenal obstruction due to extrinsic pressure is illustrated in the cases of malrotation of the large bowel. In this condition, the duodenum is compressed by the cecum and the adhesions from that structure to the right lateral abdominal wall in the subhepatic region. The following case represents such an anatomical derangement.



FIG. 2

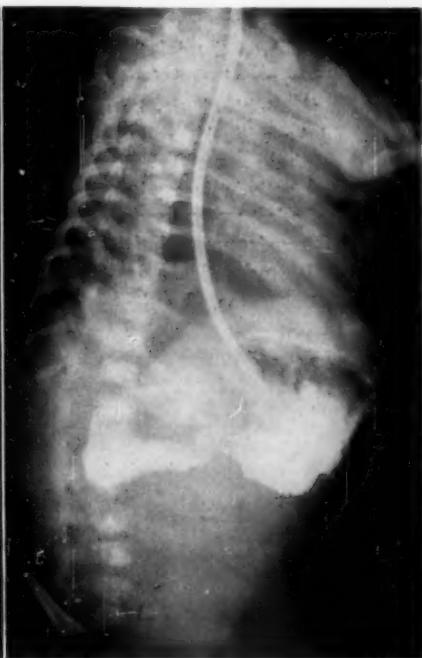


FIG. 3

FIGS. 2 and 3.—Roentgen ray reproductions of Baby R. E. showing obstruction of the distal duodenum.

Case 2.—This male infant, R. E., was admitted to Sarah Morris Hospital on January 22, 1947, at the age of nine weeks. At birth he had weighed five pounds, 15 ounces, and despite daily episodes of vomiting, he gained up to nine pounds, 4 ounces at the age of 8 weeks. Two days before hospitalization he began having projectile bile-stained vomiting. During the next 2 days his weight dropped to 8 pounds, 8 ounces and he became severely dehydrated and lethargic. On admission this dehydration was treated by subcutaneous $2\frac{1}{2}$ per cent glucose in normal saline, 10 cc. per pound body weight. Then a thin barium mixture was fed to the baby and radiographic studies revealed an

incomplete obstruction which appeared to be in the distal duodenum, about at the ligament of Treitz (see photograph). There was considerable gas in the small intestine which accounted for the infant's abdominal distension. Stool was visible in the large bowel, although obstipation was present. On the basis of these findings of projectile bile-stained vomiting, distension, and radiographically demonstrated duodenal obstruction, a diagnosis of malrotation of the large bowel was considered (see Figs. 2 and 3).

The infant was prepared for laparotomy and anesthetized with open drop ether combined with oxygen by catheter. Upon opening the abdominal cavity, through a right paramedian incision, the whole small bowel was found to be included in a volvulus. The twist of the mesentery was almost two complete turns, but the intestine was viable. In fact it was only moderately distended and only slightly cyanotic in appearance. In order to reduce the volvulus, the whole small intestine had to be delivered into the wound. The volvulus was twisted in a clockwise direction, and after reducing it counter-clockwise, the bowel was replaced within the abdominal cavity. Next the large bowel was explored and the cecum was found bound down to and compressing the underlying duodenum. The cecum was held there by bands of adhesions extending laterally to the peritoneum in the subhepatic area. These adhesions were sharply dissected, mobilizing the cecum which was then retracted to the left. By continuing the dissection, the third portion of the duodenum was exposed and found to have been constricted and obstructed by these congenital bands. With all the adhesions cut, the duodenum could be freely moved about and gas could be milked through the previously constricted area. Before placing the cecum in the left upper abdomen, the appendix was removed. This was deemed wise since any future pathologic condition of the appendix might be a difficult problem due to its position in the left upper quadrant. The small bowel was then placed between the free vertically-lying duodenum and the left-sided cecum. Closure of the abdomen was in the usual manner. Postoperatively the infant received a blood transfusion and the intravenous glucose in normal saline. By the second day, oral feedings were started with milk and water, one dram at alternating hours. Each hour the liquids were increased by one dram. No vomiting occurred and the baby was soon receiving normal feedings. On the twelfth day he was discharged from the hospital.

Case 3.—Another somewhat similar but even more interesting case is that of F. B., a five-week-old male admitted to Mount Sinai Hospital on May 4, 1948. In this patient, vomiting had been present intermittently since birth. By the day of admission, the infant's weight had dropped back to his birth weight of seven pounds, two ounces. During the several days before, his vomiting had become almost constant after any fluid intake. This vomitus was bile-stained. Dehydration ensued and the abdomen became slightly distended with a doughy consistency. The bile-stained vomitus suggested obstruction of the distal duodenum rather than pyloric stenosis. On May 6, 1948, a gavage feeding of a thin barium mixture was given. Roentgenography revealed an incomplete obstruction of the third portion of the duodenum (see Figs. 5 and 6).

In preparation for operation a cannula was tied into the saphenous vein. Premedication consisted of 1/1000 of a grain of atropine sulphate subcutaneously. Open drop ether with an oxygen catheter under the mask was administered for anesthesia. An upper right rectus incision was made and the abdomen explored. A three quarter turn partial volvulus of the entire small bowel was found and immediately corrected. The right subhepatic area was then explored and the cecum found bound down by fibrous adhesions. The cecum and adhesions covered the third portion of the duodenum. The adhesions also covered the distal ileum, binding it to the duodenum. After dissecting the bands lateral to the cecum, it could be reflected off of the duodenum revealing the appendix. The appendix was curled around the duodenum, compressing its lumen (see Fig. 4). The appendix could be removed only by first amputating it at the cecum and then ligating the mesoappendix and peeling it off the duodenum. Following this, the duodenum could be separated from the

EXTRINSIC DUODENAL OBSTRUCTION IN NEWBORN

closely adherent ileum which was on its medial aspect. This dissection was quite difficult since the blood supply to the duodenum was just beneath the ileum. After this dissection was complete, the duodenum lay as a straight, vertically-placed tube with free lumen. The cecum could then be displaced to the left and small bowel placed between it and the duodenum. Closure was in the usual manner.

During the operation a 100 cc. citrated blood transfusion was started and this was followed by a 5 per cent glucose in normal saline solution. The baby's condition was good and it was placed in an oxygen incubator bassinet for 24 hours. Penicillin, 20,000 units every 3 hours, was administered intramuscularly.



FIG. 4.—Semidiagrammatic representation of pathologic condition found in Baby F. B. Note obstruction by appendix kinked around the distal duodenum.

Gastric suction was also continued for 24 hours and then the infant was placed on the feeding schedule used after pyloroplasty. No vomiting was encountered and convalescence was uneventful. Vitamins B, C, and K were given by clysis daily. On the thirteenth postoperative day the baby was discharged from the hospital. The pathologic studies of the appendix revealed a periappendicitis.

DISCUSSION

In considering these cases, one is impressed by the ease with which the conditions can be corrected if the anatomic defects are recognized. The dissection is delicate, but no difficult anastomoses are required.

In the first case in which the anomalous artery and adhesions compressed the duodenum and common bile duct, a cholecystostomy was done to decom-



FIG. 6

FIGS. 5 and 6.—Roentgen ray reproductions showing partial obstruction of the distal duodenum in Baby F. B.

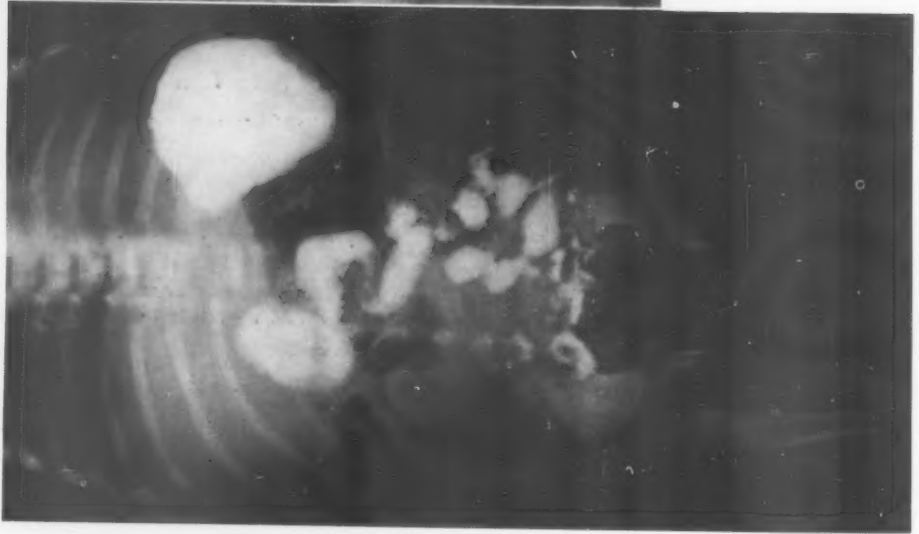


FIG. 5

press the distended biliary tract. This procedure took very little time, added only slightly to the operative risk, but insured rapid decompression in a jaundice baby with such small structures that common duct exploration would have been practically impossible. The gastrostomy was originally done to assure the operator that the duodenal lumen was adequate. However, I believe the use of this catheter extending into the jejunum for feeding was, in a large measure, responsible for the successful postoperative result. I do not believe that this weak, premature infant of only three pounds could have taken enough food orally to recover. Amigen fed through the tube supplied an immediate source of protein-building essentials which required no digestion.

Malrotation of the large bowel frequently produces intestinal obstruction. This has been pointed out by Ladd and Gross,¹ Gardner and Hart,³ and by Dott.² However, I do not believe the factor of duodenal obstruction by this same malrotation has been sufficiently stressed. In freeing the cecum and its adhesions, the duodenal patency must be assured. Duodenal obstruction must be considered in malrotation of the large intestine just as the latter condition must be looked for when small bowel volvulus is found in infancy. In malrotation, the terminal ileum and jejunum are suspended from almost the same point allowing twisting to occur easily.

In these cases, the volvulus must be untwisted first. Then the cecum and its adhesions must be freed until it can be reflected to the left allowing clear visualization of the duodenum. At this point, the duodenum will follow almost a straight vertical course. The small bowel can then be replaced between the duodenum and the cecum which now lies in the left upper quadrant. In this way the terminal ileum is carried away from the duodenum, making a recurrence of the volvulus less likely.

Abdominal surgery in the premature and newborn infant can safely be done with open drop ether anesthesia if oxygenation is aided by an oxygen catheter placed under the ether mask.

The age or size of the infant need not discourage surgical intervention in these cases if all precautions are taken and the procedures are done gently, carefully, and rapidly.

BIBLIOGRAPHY

- ¹ Ladd and Gross: *Abdominal Surgery in Infancy and Childhood*. 1941, Phila., W. B. Saunders Co.
- ² Dott, N. M.: *Anomalies of Intestinal Rotation*. *Brit. J. Surg.*, **11**: 251, 1923.
- ³ Gardner and Hart: *Anomalies of Intestinal Rotation as a Cause of Intestinal Obstruction*. *Arch. Surg.*, **29**: 942, 1934.

MENINGOCELE SPINALIS TRAUMATICA SPURIA*

CASE REPORT OF AN UNUSUAL COMPLICATION OF SPINAL INJURY
WITH OPERATIVE CURE

ALFRED L. SHAPIRO, M.D., AND LEO FASKE, M.D.

NEW YORK, N. Y.

FROM THE DEPARTMENT OF TRAUMATIC SURGERY OF THE CUMBERLAND HOSPITAL, BROOKLYN

MENINGOCELES IN ADULTS, whether congenital or acquired, constitute an exceedingly rare type of neuro-pathologic disorder. Chambers and Revilla,¹ as late as May, 1948, reporting from the Johns Hopkins Hospital, found only one instance of a spinal meningocele in an adult. No similar cases were discovered in their search of the literature. Their case report concerned a 53-year-old male with a progressively increasing lumbosacral protrusion and advancing neurologic changes beginning in adult life, 17 years before hospital admission. A known small protrusion in the lumbosacral region had been present since birth which began to increase in size at the age of 32, ultimately attaining the dimensions of a grapefruit. The patient suffered marked dysuria, had to catheterize himself several times a day, and developed extreme weakness and emaciation of the lower extremities. The spinal mass was tender; pressure precipitated marked headache and lancinating pains down the legs.

The only clearly analogous references to the condition of traumatic spinal meningocele appear to be in the papers of Dobrzaniecki and Haak,² Chadkow,³ Schmidt,⁴ and Wolynski.⁵ The first authors describe a case of anterior sacral fracture in which a soft fluctuant mass was found over the coccyx, and in the pelvis lying anterior to the sacrum. On digital pressure rectally a pounding headache was induced. Lumbar puncture and puncture of the coccygeal protuberance both gave clear cerebro-spinal fluid. After five months this case appeared to heal spontaneously.

Wolynski⁵ described a nontraumatic anterior sacral meningocele discovered in a 24-year-old male on rectal examination. Puncture of the mass rectally yielded spinal fluid; however, the patient died of a *B. coli*-meningitis. Chadkow³ presents a case following gunshot wounds in the upper spine with bi-lateral paraplegia.

It is noteworthy that most standard textbooks of neuro-surgery⁶⁻⁸ appear to make no reference whatsoever to this condition although Marburg⁹ discusses briefly the more common "cephalohydrocele traumatica" following skull fractures in children. Bancroft¹⁰ alludes, without further detail, to the possibility that meningoceles may develop after disc operations and laminectomies, if the dura is not adequately closed.

The so-called traumatic *cephalo*-meningoceles, although uncommon, have been presented in the literature a number of times. They have been reported after skull injuries,¹¹⁻¹⁶ mastoid operations, orbital surgery and similar pro-

* Submitted for publication February, 1949.

cedures. A number appeared to be transient,¹¹ some disappeared after compressive dressings,¹² and others, particularly if of many years duration, were operated on, in a number of instances successfully. It is of interest to note the etiologic explanation for this condition proposed by several authors.^{5, 16, 18} They believe that the Pacchionian bodies become in some way obstructed or impeded, interfering with the reabsorption of the cerebro-spinal fluid secreted by the choroid plexus. It is somewhat difficult to correlate this change, conceivable in cases of head injury, with the development of meningoceles following spinal canal wounds. However, the present authors propose no interpretation of the mechanics involved other than to note that in our case there appeared to be no unusual postoperative increase in cerebro-spinal pressure or any intracranial difficulties following extirpation of the sac. However, the fact that our patient had a forceful dry cough several days following his initial hospital admission might be of contributory significance in that an intermittent spinal hydrostatic pressure increase may have prevented the healing of the dural perforation resulting from the original stab wound.

Case Report.—On August 23, 1948, a 24-year-old male Negro (K. C.) was admitted to the hospital from the emergency room. He had been in a brawl with several men, and was stabbed in the lumbo-sacral region. The skin had been closed with three black silk sutures by the admitting officer. The patient was able to walk and stand and was admitted primarily because of syncope and weakness following treatment. There was a pronounced alcoholic odor on the breath, although the patient was quiet and cooperative.

The patient's history was noncontributory. Serological, blood, and urine examinations were normal. The patient had been in relatively good health, and had seen army service in this country without incident. Blood pressure was 90/66. There was a two-inch laceration over the lumbo-sacral region to the right of the median line. Roentgen ray examination of skull and chest were negative. The patient's course in the hospital continued uneventful until September 1, when he complained of headache and stiffness of the neck. The temperature was 100° at this time. A watery discharge was noted coming from the site of the previous laceration. On penicillin therapy the patient's symptoms disappeared in two days, and the laceration appeared healed and dry within three days. However, on September 8, while examining the patient for the anticipated purpose of recommending him for discharge from hospital, a soft swelling, about 2 cm. to the right of the lumbo-sacral articulation, at the site of the apparently healed stab wound, was discovered. The swelling was hemispherical, about 6 cm. wide and 3 cm. high, and pulsated almost synchronously with the heart beat. The patient, however, did not complain of pain in the extremities, back or head on pressure over it. Needle aspiration revealed the sac contents to be clear colorless fluid, apparently cerebrospinal fluid.

Pantopaque myelography was performed and the contrast medium was found to enter the sac freely from the spinal canal. A communicating tract on the right side was demonstrated at the level of the lumbo-sacral articulation.

On September 16 an exploratory laminectomy was carried out. A large thick walled pear-shaped sac 10.5 cm. long and 5.5 cm. wide was encountered and dissected free. The contents were clear cerebrospinal fluid. The sac lining was smooth, gray-pink, and glistening, and posteriorly was adherent to overlying skin. The lining and wall were continuous with the spinal dura-arachnoid in the right sub-laminar portion of the lumbo-sacral space. The communicating aperture was almost 2 cm. in width, and readily admitted the tip of the little finger. Several large sized probes could be introduced together. The dural perforation was closed with several fine catgut sutures. An Albee

type spinal fusion was performed and the patient was placed in a body spica. Except for a transitory inability to void on September 18, which cleared up after catheterization and the use of pilocarpine, the patient's convalescence was relatively uneventful. No motor or sensory neurologic residual sequelae of consequence developed. The patient was discharged on October 14, one month postoperatively, as cured. He has been in our follow-up clinic several times and has had no complaints. The histopathologic report stated that the sac wall consisted in the main of connective tissue lined in several areas by a single layer of flattened mesothelium-like cells. Interspersed with the collagenous tissue were occasional nervous tissue elements.

BIBLIOGRAPHY

- ¹ Chambers, J. W., and A. G. Revilla: Unusual Case of Meningocele in an Adult. *J. Neurosurg.*, **5**: 316, 1948.
- ² Dobrzaniecki, W., and E. Haak: Meningocele Spinalis Traumatica Spuria. *Ann. Surg.*, **116**: 150, 1942.
- ³ Chadkow, C.: Meningocele Spinalis Traumatic Spuria. *Zentrbl. f.d. ges. Neurol. u. Psych.*, **43**: 330, 1926.
- ⁴ Schmidt, D.: Über die Meningocele Spinalis Spuria Traumatica. *Jahresb. u.d. Leist. w. Fortschhr. auf. d. Ges. d. Neur. w. Psych.*, **5**: 678, 1901.
- ⁵ Wolynski, A.: False Traumatic Meningocele. *Polska gaz. lek.*, **15**: 261, 1936.
- ⁶ Elsberg, C. A.: Surgical Diseases of the Spinal Cord, Membranes, and the Nerve Roots. 1941, P. B. Hoeber, N. Y.
- ⁷ Brock, S.: Injuries of the Skull, Brain, and Spinal Cord. 1943, Williams and Wilkins, Baltimore.
- ⁸ Albee, F. H., *et al.*: Surgery of the Spinal Column. 1945, F. A. Davis, Phila.
- ⁹ Marburg, O., and M. Helford: Injuries of the Nervous System. 1939, Veritas, N. Y.
- ¹⁰ Bancroft, F. W. (ed.): Surgical Treatment of the Nervous System. 1941, J. B. Lippincott Co., Phila.
- ¹¹ Bozson, E. J., and T. I. Brennan: Transient False Meningocele. *Am. J. Surg.*, **47**: 334, 1940.
- ¹² Froelich, M.: Meningocele Traumatique. *Rev. Med. de l'est. Nancy*, **52**: 337, 1924.
- ¹³ Haynes, I. S.: Traumatic Meningocele. *Ann. Surg.*, **53**: 268, 1911.
- ¹⁴ Heully, L.: Un Cas de pseudo-meningocele traumatique bilaterale. *Rev. Med. de l'est. Nancy*, **41**: 329, 1909.
- ¹⁵ Schindler, R.: Ein Fall von Meningocele Spuria Traumatica. *Jahrb. z. Kinderh.*, **76**: 160, 1912.
- ¹⁶ Hetsted, R.: Zur Behandlung der Meingocele Spuria Traumatica. *Arch. f. Klin. Chir.*, **98**: 1076, 1912.
- ¹⁷ Bianchi, G.: False Traumatic Meningocele. *Radiol. Med.*, **18**: 347, 1931.
- ¹⁸ Winkler, J.: Beitrag sur Kasuistik der Meningocele Traumatica Spuria. *Wien. Klin. Wchnschr.*, **24**: 1274, 1911.

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY.

John H. Gibbon, Jr., M.D.

1025 Walnut Street, Philadelphia 7, Pa.

Contributions in a foreign language when accepted will be translated and published in English.

Exchanges and Books for Review should be sent to Dr. Gibbon at the above address.

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY

East Washington Square, Philadelphia 5, Pa.

Editorial . . .

GENERAL SURGERY

"HAVE SOME GENERAL SURGERY," the March Hare Specialty Board said in an encouraging tone.

Alice looked all round the country but there was nothing but specialty surgery. "I don't see any general surgery," she remarked.

"There isn't any," said the March Hare Specialty Board.

* * * * *

As long as lamentation about the diminishing scope of general surgery was merely an emotional genuflexion in some nostalgic presidential address, or an expression of wounded vanity in the surgeon's dressing room, there was no need to take it seriously. Indeed there is no need to make a to-do over it now, except to point out that if we really want to accomplish anything by these fumbling discussions about general surgery, they should be centered on a problem of semantics and not on who does what in the morning's operating list. There is reason to believe that the whole affair might not be too difficult to solve if we set our minds to it.

Evidence that fuzziness in the usage of words actually bogs down our workaday world is present on all sides. Certainly, young surgeons will agree that specialty boards should be able to define exactly what is meant when general surgery is prescribed in training specifications; but there is no reason to believe that this has ever been attempted. Again, our surgical publications seem to be getting into a pretty muddle. Take a glance at the two fine volumes entitled "Operative Technic" just off the press under the able editorship of Warren H. Cole. One volume is dutifully labeled "General Surgery" and the other "Specialty Surgery." The material in the book may be beyond reproach, but if there was any rhyme or reason that determined why certain topics were placed in one of the volumes instead of the other, I fail to see it.

The start of our present difficulty was the usage of the term *general surgery* to describe *that range of operative surgery that is spanned by the technical competence of an individual who calls himself a general surgeon*. It thus became a subjective rather than an objective classification. When this range of technical competence was narrowed to a single anatomico-topographic region it was christened specialty surgery. As long as the range encompassed two or more regions (always including the belly), it was called general surgery. But this division of surgery on the basis of what operations a surgeon performs no longer makes sense. I doubt if a surgeon exists who would take even a sporting go at the operations described in Cole's Volume I and pass along the operations in Volume II to specialty colleagues.

Now there is a way out of this difficulty, but before considering it let's take a look at the end of the spectrum of surgery that borders on the basic sciences

rather than the operating table. Here there is also a pretentious and confused usage of words. That part of pathology important to surgeons became *surgical pathology* long ago; that portion of physiology vital to surgical practice has turned into *surgical physiology*; now there is *surgical bacteriology*, and so on. Are we to have *surgical chemistry*, *surgical physics* and eventually *surgical mathematics*? This is all just as ridiculous as the way we have boggled the definition of general surgery.

It might all be straightened out for the next generation if the word *general* could be torn loose from its subjective roots and used with the same meaning that Billroth and his contemporaries used the term *allgemeine* as applied to *Chirurgie*. Literally translated *allgemeine* means general, but in the sense of basic or fundamental principles that have been established by the inductive methods of science. To revive this concept of the word *general* and thus to redefine *general surgery* on an objective basis would reestablish a natural division of the subject matter of surgery. Those parts of any science pertinent to the applied science of surgery would be a concern of this general surgery. Billroth envisioned only the surgical applications of pathology, so this became the substance of his *allgemeine Chirurgie*; we have in addition, the other medical and natural sciences. Systems of technics that are applicable to all surgery, such as sepsis, anesthesia and hemostasis would be placed in general surgery; and here also would be found the knowledge and experience concerning those adjuvants to operative surgery that are so vital to preoperative and postoperative management.

All technical considerations peculiar to an anatomico-topographic region, including the abdomen, would then become specialty surgery. General surgery for example, would deal with considerations common to all wounds; specialty surgery with wounds of the abdomen, wounds of the chest or of the extremities. But all specialty surgery would be dependent on general surgery.

What then would become of the general surgeon? Like the comedian who pulls a long rope across the stage and disappears into the wings only to reappear immediately from the opposite wings pulling on the other end of the same rope, there would be a renaissance of the general surgeon, but in the full vigor of youth.

Once we put our own surgical house in order and can persuade our colleagues to do the same with internal medicine, it then might be feasible to convince medical faculties that orderly thinking could be applied to the undergraduate curriculum. But that is another story.

EDWARD D. CHURCHILL.